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A prospective, proteomics study identified potential biomarkers of encapsulating peritoneal sclerosis in peritoneal effluent.

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Abstract:

Encapsulating peritoneal sclerosis (EPS) is a potentially devastating complication of peritoneal dialysis (PD). Diagnosis is often delayed due to the lack of effective and accurate diagnostic tools. We therefore examined peritoneal effluent for potential biomarkers that could predict or confirm the diagnosis of EPS and would be valuable in stratifying at-risk patients, and driving appropriate interventions. Using prospectively collected samples from the Global Fluid Study and a cohort of Greek PD patients, we utilized 2D SDSPAGE/ MS and iTRAQ to identify changes in the peritoneal effluent proteome from patients diagnosed with EPS and controls matched for treatment exposure. We employed a combinatorial peptide ligand library to compress the dynamic range of protein concentrations, to aid identification of low-abundance proteins. In patients with stable membrane function, fibrinogen γ -chain and heparan sulphate proteoglycan core protein progressively increased over time on PD. In patients who developed EPS, collagen- α 1(I), γ -actin and Complement factors B and I were elevated up to five years prior to diagnosis. Orosomucoid-1 and a2-HS-glycoprotein chain-B were elevated about one year before diagnosis, while apolipoprotein A-IV and α 1-antitrypsin were decreased compared to controls. Dynamic range compression resulted in an increased number of proteins detected with improved resolution of protein spots, compared to the full fluid proteome. Intelectin-1, dermatopontin, gelsolin and retinol binding protein-4 were elevated in proteome-mined samples from patients with EPS compared to patients that had just commenced peritoneal dialysis. Thus, prospective analysis of peritoneal effluent uncovered proteins indicative of inflammatory and pro-fibrotic injury worthy of further evaluation as diagnostic/prognostic markers.

Keywords: peritoneal dialysis, encapsulating peritoneal sclerosis, biomarkers, proteomics

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Introduction:

Encapsulating peritoneal sclerosis (EPS) is a rare complication of peritoneal dialysis (PD) resulting in significant morbidity and mortality⁽¹⁾. Overall reported life-time risk ranges from 0.54%⁽²⁾ to 3.3%⁽³⁾. Incidence increases with the duration of PD treatment⁽⁴⁻⁶⁾, ranging from 0.7%⁽⁴⁾ to 8.1%⁽⁵⁾ at 5 years and from 2.1%⁽⁴⁾ to 19.4%⁽⁶⁾ at 8 years. The development of EPS has been associated with numerous factors including glucose load, rapid solute transport status and intraperitoneal inflammation, requirement for icodextrin use, ultrafiltration failure associated with reduced free water transport, modality change, young age and genetic predisposition⁽⁷⁻¹⁴⁾.

The pathogenesis of EPS remains poorly defined but multiple “hits” appear to be required in patients predisposed to peritoneal injury by uremia and dialysis solution exposure.⁽¹⁵⁾ Although episodic infection, epithelial-to-mesenchymal transition (EMT)⁽¹⁶⁾ and the involvement of uncontrolled inflammatory cascades (TGF-beta, VEGF etc.)⁽¹⁷⁻²⁰⁾ may be contributory factors, to date no single definitive pathway has been identified.

Clinical signs of EPS include persistent or recurrent bowel dysfunction and nutritional impairment⁽¹⁾. Diagnosis is confirmed at laparotomy or on PET/CT imaging⁽²¹⁾, but the rarity of the disorder, variable presentation and lack of screening tools frequently lead to delayed diagnosis. Peritoneal dialysis effluent (PDE) biomarkers that could predict the onset or confirm the diagnosis of EPS would allow the development of prognostic tools and, potentially, the identification of future therapeutic targets. Proteomics technologies provide us with powerful tools for an in-depth exploration of the PDE proteome, yet relevant studies have been few and to date preliminary⁽²²⁻³⁸⁾.

In the present study, we have used an optimised proteomics approach to detect prospective changes in the PDE proteome of clinically well-described patients from the Global Fluid Study (GFS) cohort who subsequently developed EPS. Controls were patients from the same cohort with stable membrane function who did not subsequently develop EPS. EPS and stable patients were matched for time on treatment or time to developing EPS/stopping PD. The aim of this study was to identify

1 proteins in the drained PD effluent whose measurement might predict the onset of EPS. Further
2 analysis, using a cohort of Greek PD patients, utilized methods to allow detection of lower abundance
3 proteins by using a combinatorial peptide ligand library (CPLL). Based on these experiments, our data
4 identifies proteins whose expression changes in EPS patients and in some cases are expressed in
5 PDE significantly in advance of clinical diagnosis. These data support growing evidence that EPS is
6 preceded by inflammatory and fibrotic peritoneal injury and would seem worthy of further exploration
7 as candidate markers of EPS diagnosis and monitoring.
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Results:

Determination of protein changes with time on PD in patients with stable peritoneal membrane function

To ascertain the time-course of changes in the levels of proteins in PDE, samples from 5 patients with at least 10 sequentially collected effluent samples spanning a period of >4 years on PD, were analysed by 2D PAGE. Over 800 protein spots were consistently detectable in all samples when analysed by PDQuest. The majority of these proteins were relatively constant in expression providing confidence of the validity and fidelity of the methodology selected (Figure 1). PDQuest identified approximately 25 spots that either increased (x2) or were reduced (x2) in intensity in a progressive manner with dialysis duration. Of these, however, only 2 spots were consistently changed in greater than 4 out of the 5 patient samples evaluated. Mass spectrometry identified these proteins as fibrinogen γ -chain (Figure 2a) and Heparan-Sulphate Proteoglycan (HSPG) (Figure 2b). Based on spot intensities, fibrinogen γ -chain began to be elevated after approximately 30% of total dialysis duration before plateauing while HSPG levels showed a progressive increase over the entire duration of PD treatment.

Determination of protein changes in patients that developed EPS

A. 2D SDS PAGE MS proteomics

To determine which proteins were changing in patients who were ultimately diagnosed with EPS, 6 UK patients from the GFS, who had EPS diagnosis confirmed by CT scan, and who had ≥ 4 sequential samples prior to this diagnosis were selected. Each of these patients was matched to a patient from the same centre according to the following criteria: equal exposure to PD treatment, comparable sampling points from the time of initiation of PD, stable membrane function and lack of any evidence indicative of EPS (see Supplemental Table 1 for time point matching details). The Dodeca gel system that was used for the study runs a maximum of 12 gels, so 6 EPS gels and 6

matched control sample gels was the maximum comparison that could be performed in a single experiment. Twenty four spots were identified in all the EPS patients as being differentially altered over time compared to the matched patients control samples. Of these, 2 spots were identified as being altered consistently in all of the 6 EPS patients in comparison to the control patients. Collagen- $\alpha 1(I)$ became elevated in EPS patients (Figure 3a) typically after 30% of total dialysis duration, while γ -actin (Figure 3b) was frequently elevated very early (124-1043 days) and remained elevated throughout the entire duration of PD (maximum duration was 2868 days) until EPS was diagnosed clinically. In 5 out of the 6 EPS patients, changes in spots subsequently identified as complement factors B and factor I were seen (Figure 4). The complement factor B spot was either not present or barely detectable in matched patients with stable membrane function, but was elevated (in some patients up to 6 years before EPS was diagnosed) and remained elevated (above matched control levels) in those patients who were subsequently diagnosed with EPS. The Complement factor I spot was present in both patient groups and decreased slightly with duration of PD. It was, however, at consistently higher density at each time point in those who subsequently were diagnosed with EPS. $\alpha 1$ -antitrypsin and apolipoprotein A-IV spots appeared at noticeably lower intensity in 3 out of 6 EPS patients.

B. Isobariq tagging for relative and absolute quantification (iTRAQ) proteomics.

2D SDS-PAGE is a labour-intensive approach, with analysis limited by the accuracy of spot mapping software that subsequently needs a high degree of manual mapping and is subject to data losses. To address these issues we optimised a mass spectrometry based iTRAQ protocol for use with PDE samples and repeated the comparisons in one EPS and matched control sample pair. An 8 iTRAQ approach was used allowing comparison of 4 time points from each patient. A limitation of iTRAQ is the low rate of protein detection, however 72 proteins had sufficient sequence recognition to allow for robust protein identification (Table 1). Of these, by performing ratio analysis of the isobariq tag from each patient at each time point it was possible to identify 4 consistent trends (Figure 5).

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Orosomucoid-1 and α 2-HS-glycoprotein chain B were both elevated in the EPS patient approximately 12 months prior to diagnosis, while Apolipoprotein A-IV was always lower in EPS. There was also a late drop in serotransferrin levels at EPS onset.

Protein mining.

From both SDS-PAGE and iTRAQ it was evident that >95% of the total protein load detected was highly abundant serum proteins such as albumin and IgG (Figure 6A). This meant that <5% of the proteins being analysed were ones of potential interest. To address this, a protein-mining approach was used employing the Bio-Rad® ProteoMiner™ enriching system to reduce the dynamic range of abundant protein concentrations, while maintaining the relative levels of less abundant proteins. In comparison to the full fluid proteome where approximately 800 spots were identified (many of which were related) (Figure 6A), post ProteoMiner™ analysis the same protein concentration yielded >2000 discrete protein spots that were all well resolved (Figure 6B).

Determination of lower abundance proteins changing in patients that developed EPS using 2D SDS-PAGE/MS proteomics on samples subjected to ProteoMiner.

Protein mining required a starting protein mass of approximately 15mg, to produce 60µg of protein for proteomic analysis. In the GFS cohort, sufficient individual patient PDE was not available for this type of analysis. However, as part of a collaborative study with the University of Patras, Greece, we were able to obtain significant PDE volumes from 3 patients with suspected EPS. These samples were compared to 3 prevalent patients with stable membrane function who had been on PD for >5 years and with 3 incident patients from the same centre. All 9 samples were subjected to ProteoMiner™ analysis, fractionated by 2D-SDS PAGE and compared using PDQuest™. From this analysis, three spots were detected that were elevated only in the PDE of patients with EPS. Intelectin-1 (Figure 7a) was barely detectable in patients just starting PD or in patients who had been on PD for >5 years. However, in patients with suspected EPS a strong protein spot was visible.

Likewise, dermatopontin (Figure 7b) was also strongly expressed in EPS patients, but was only mildly elevated in 1 of the 3 prevalent patients and not at all in patients starting PD. Retinol binding protein-4 (RBP-4) was also identified as increasing in EPS patients (not shown). There were numerous additional spots seen but we were subsequently unable to identify them in our MS analysis.

Patient pooling to facilitate protein mining and ITRAQ on the GFS cohort

To combine the benefit of protein-mining, the sequential sampling of patients in the GFS, the power of the iTRAQ approach and provide sufficient protein for meaningful analysis, we combined GFS effluent samples from several patients into 4 groups based on time on dialysis for both stable PD patients and for those developing EPS. Samples were pooled in to Group 1; within 6 months of EPS or stopping dialysis, Group 2; 6-12 months prior to stopping dialysis, Group 3; 12-24 months prior to stopping dialysis and Group 4; >24 months before cessation of dialysis. Each pool of fluid (~18mg of protein, see supplemental table 2 for pool composition detail) was protein-mined using proteominer, iTRAQ-labelled and analysed by MS as previously described (Figure 8).

Analysis identified >2,000 detectable proteins and sequence recognition allowed robust identification of 136 of these proteins. Hierarchical cluster analysis showed a clear demarcation of proteins found between those who develop EPS and the control-matched patient samples (Figure 9a). Heat map analysis (Figure 9b) demonstrated higher levels of many of these proteins in the EPS effluent samples across all time points analysed. Subsequent analysis of the ratios of relative changes in individual proteins between EPS and non-EPS patients with time was disappointing, in that consistent progressive changes with time for individual proteins were limited compared to numerous ratio shifts at individual time points. Nevertheless, the data confirmed the previously observed increases in intelectin-1 expression and a small reduction in Apolipoprotein with both A-II & A-chains being reduced in samples from patients subsequently developing EPS. Interestingly, despite numerous changes being observed at each time point only two additional proteins appeared to change progressively. Multiple Haemoglobin subunits were dramatically increased within the last 12 months in

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2 EPS patients despite no macroscopic evidence of blood in the PDE samples, whilst Gelsolin showed a
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4 progressive accumulation with time (Figure 10).
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8 **Discussion:**
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10 The combination of uraemic milieu and chronic exposure to PD solutions induce the
11 development of structural changes in the peritoneum⁽³⁹⁻⁴⁰⁾. There is significant interest as to whether
12 these histological changes can be correlated with or predicted by changes in effluent proteins
13 (irrespective of source) and whether the levels of these proteins are altered with duration of PD. Such
14 protein changes, if consistent, might provide easily detectable effluent biomarkers of distinct peritoneal
15 pathology or have routine prognostic value. In the present study we chose to screen for effluent
16 proteins in defined groups of PD patients using a broad-based proteomics approach. We used
17 prospectively collected PDE samples from the uniquely characterized patients in the GFS cohort to
18 examine if specific proteins were identifiable and ask if any of these were specifically changed in
19 patients who subsequently developed EPS. The 16 proteins identified across all proteomics
20 approaches, (which employed up to 10 patients that developed EPS, matched with 18 with stable
21 function) are summarized in table 2. Given that the function of some of these proteins is already
22 known, we can hypothesise as to their potential role in EPS.
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39 Fibrin deposition is a feature of peritoneal fibrosis and EPS pathology⁽¹⁵⁾. Fibrin is derived from
40 fibrinogen and both are involved in inflammatory processes. In PDE fibrinogen γ -chain increases
41 during peritonitis and declines after successful treatment⁽²⁸⁾. Our results indicate that the amount of
42 fibrinogen γ -chain in PDE begins to increase after 6-18 months on PD and plateaus thereafter. As
43 major histopathological changes in the dialysed peritoneum begin to manifest fully after ~2 years on
44 PD⁽³⁹⁾, the pattern of fibrinogen γ -chain elevation might reflect the evolution of processes that
45 contribute to the establishment of peritoneal fibrosis. Fibrinogen γ -chain may thus become elevated
46 as fibrogenesis is initiated and plateau when fibrosis becomes established. Peritoneal fibrosis is also
47 characterised by increased turnover of extracellular matrix (ECM). This process might be reflected by
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the progressive increases of HSPGs⁽⁴¹⁾ in PDE, as they are key components of basement membranes.

Using 2D SDS-PAGE/MS, we observed increases in the concentrations of collagen- α 1(I) and γ -actin in the PDE of 6 patients subsequently diagnosed with EPS. These changes were not seen in the matched control patients. Elevation of collagen- α 1(I) may reflect increased ECM turnover and the deposition of type-I collagen in the peritoneal tissues⁽⁴²⁾. Expression of collagen- α 1(I) mRNA is up-regulated in EPS patient peritoneum, while its accumulation in the sub-mesothelial compact zone and EPS-derived tissue has been demonstrated by immunostaining⁽⁴³⁻⁴⁴⁾. Remodelling of γ -actin cytoskeleton is a feature of EMT⁽⁴⁵⁾. Early elevation of γ -actin in PDE might be the result of its release from damaged peritoneal tissues⁽⁴⁶⁾. Interestingly, the changes in γ -actin are consistent with the observed increases seen in gelsolin in the pooled EPS cohort samples. Gelsolin is an actin-binding protein that is a key regulator of actin filament assembly and disassembly and one of the most potent members of the actin-severing gelsolin/villin superfamily. Its elevation might help to explain the increased γ -actin levels observed in PDE.

In contrast, α 1-antitrypsin and apolipoprotein A-IV were both at noticeably lower levels in patients diagnosed with EPS. α 1-antitrypsin (1-PI) is an inhibitor of ECM proteases including plasmin and suppresses the inflammatory response in PDE by inhibiting PAF biosynthesis. Blocking of 1-PI by oxidants during inflammatory process allows for increased production of PAF and unrestrained synthesis of inflammatory mediators⁽⁴⁷⁾. Apolipoprotein A-IV has anti-inflammatory⁽⁴⁸⁾ properties. Therefore, lower levels of 1-PI and apo A-IV may indicate an active inflammatory process which might contribute to EPS development⁽⁴⁹⁾. The latter is further supported by the observed increases in Complement factor expression⁽⁴³⁾. Complement Factor I and factor B were consistently detected prior to (years before) and remained elevated in all patients who subsequently developed EPS. Upon activation of the alternative pathway, Factor B is cleaved by complement factor D yielding the catalytic subunit Bb. The active subunit Bb associates with C3b to form the alternative pathway C3-convertase, driving subsequent complement activation and inflammation. Factor I (also known as

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2 C3b/C4b inactivator) is a key regulator of downstream complement activity and its elevated levels are
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4 a further indicator of ongoing inflammatory activation in EPS patients.
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6 Using iTRAQ analysis we demonstrated alterations in the effluent concentrations of acute
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8 phase proteins (APP). Orosomucoid-1 and a2-HS-glycoprotein chain B were both elevated in EPS
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10 patients >12 months prior to diagnosis whilst Apolipoprotein A-IV was always low in EPS patients.
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12 Orosomucoid-1 is a major APP. Its concentration increases several-fold in response to inflammation,
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14 infection or systemic tissue injury⁽⁵⁰⁻⁵¹⁾. In PD patients, its dialysate levels increase during
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16 peritonitis⁽⁵²⁾. Alpha2-Heremans-Schmid glycoprotein (AHSG), or fetuin-A, has been suggested as a
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18 negative APP of inflammation⁽⁵³⁾ but as a positive APP of injury⁽⁵⁴⁾ and as an antagonist of TGF- β ⁽⁵⁵⁾.
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20 The observed increase of these two molecules in the PDE, months before the onset of overt EPS,
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22 might underline a potential prognostic value. Serotransferrin is the major iron transporter and is down-
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24 regulated in inflammatory conditions⁽⁵⁶⁻⁵⁷⁾. The observed late drop of serotransferrin levels might thus
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26 also reflect an increased inflammatory event that is critical in the establishment of full-blown EPS
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28 symptoms and pathology.
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32 Complex biological samples are characterised by a high dynamic range of protein
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34 concentrations⁽⁵⁸⁾, posing a major challenge in proteomic analyses⁽⁵⁹⁾ as less abundant components
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36 are far more likely to be useful as biomarkers. Combinatorial peptide ligand libraries (CPLL) can
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38 compress the dynamic range by altering the proportion of abundant versus non-abundant proteins⁽⁶⁰⁾.
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40 This approach was preferred over depletion protocols, where proteins of potential interest may also be
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42 removed non-specifically by sticking to depleted proteins such as albumin. Recovery of <1% of
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44 treated protein, increased the number and improved resolution of spots, indicating that proteome-
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46 mining was successful and increasing the sensitivity of 2D SDS-PAGE. Variability in spot intensities
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48 indicates that quantitative information was not lost during the mining process. Comparisons between
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50 gels from CPLL-mined samples identified that intelectin-1, dermatopontin and retinol binding protein-4
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52 appeared to be elevated in PD patients diagnosed with EPS compared to matched controls or those
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54 just starting on PD. Intelectin-1 is an adipocytokine involved in intestinal host defences⁽⁶¹⁾.
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2 Dermatopontin is an ECM protein that regulates the function of TGF- β by interacting with the
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4 proteoglycan decorin⁽⁶²⁾. Its presence in PDE might thus indicate increased turnover and accumulation
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6 of ECM in the peritoneum⁽⁶³⁾, being consistent with changes in Collagen 1 and HSPG.
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9 Overall the primary aim of this study was to identify early biomarkers for subsequent validation
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11 that would predict later risk of EPS. This has been successful in identifying changes in Collagen
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13 $\alpha 1(1)$, γ -Actin, complement I & B as well as anti-trypsin up to 3 to 5 years before EPS onset, with
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15 Gelsolin, Apo AII, Apo-AIV & haemoglobin β changing at least 2 years before onset, although caution
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17 should be exercised with these time frames due to the large variation in time on PD between the
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19 matched populations. The study also identified late markers such as serotransferrin, Orosomucoid-1,
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21 Alpha-2-HS-glycoprotein chain B and intellectin-1 which may have diagnostic value when combined
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23 with symptoms. One could further hypothesise that this data supports the multiple hit theory of EPS
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25 with early, mid and late protein changes in that there may be a time-point where a “second hit” drives
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27 the process into the EPS pathway post an initial hit priming the system (eg. reflected by changes in
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29 Collagen I and Actin). From that time on, the inflammatory and other processes that lead to the
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31 development of EPS may need 6-12 months to fully develop into a recognisable clinical syndrome. Its
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33 thus likely, and reflected here, that biomarkers would fall into the same 2 categories.
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37 While of interest, the robustness of our findings is significantly limited by the low number of
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39 patients available for suitable stratification and the limited numbers that can be compared in these
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41 proteomic approaches. The GFS is one of the world’s largest PD cohort studies, yet has limited EPS-
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43 to-control matching options, resulting in some differences in descriptive data to remain apparent. As
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45 with all previous studies in this area, it is possible that differences in measured and unmeasured
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47 confounders could be biasing the results. Further, the selected proteomics approach was not able to
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49 determine the source of the proteins identified in this analysis and a possible spill-over effect from
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51 plasma cannot be excluded which needs to be addressed in ongoing investigations.
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55 Previous studies have suggested that a number of proteins, primarily inflammatory biomarkers
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57 (IL-6, TNF- α , MCP-1, CCL-15, PAI-1), were slightly increased in the PDE of patients who
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1 subsequently developed EPS^(10,49,64-65), but were not identified by our proteomics approach. Previous
2 studies used a targeted ELISA based approach, which has high sensitivity and subsequently
3 resolution. Proteins identifiable with ELISA may subsequently fall below the detection limit of the
4 proteomics approaches described, especially where protein-mining was not undertaken. Further, the
5 proteomic technique may be unable to see the protein in the matrix used. Protein spots may not
6 resolve, while high-matching criteria (4 peptides minimum) may have disadvantaged detection of
7 smaller proteins. Alternatively, proteins may have not flown in the MS or not label with an isobariq tag.
8 Finally, the small number of patients, the frequency of the change (i.e. spot changes in >75% of
9 comparisons) or its magnitude could impede identification. Multiplexing approaches are more
10 sensitive and quantitative, and could have been used here. However the investigator must select the
11 list of proteins to measure, which precludes discovery of new protein involvement. Further these
12 approaches demand high sample number and would not add power to the results described due to the
13 very small number of EPS samples in the GFS cohort.
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30 In contrast, the strengths of this study lie in its prospective nature, its unbiased nature and
31 multiple proteomic approaches. Prospective analysis has resulted in identifying changes that occur
32 consistently over time (and prior to disease onset in many cases), are robust across multiple
33 comparisons and differentiate between EPS and control patients. The discovery-based approach, has
34 allowed the analysis to be undertaken without prejudice for already known proteins and pathways,
35 thus reducing protein selection bias and potentially allowing the discovery of novel markers of
36 peritoneal fibrosis and EPS.
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45 Collectively, the study results demonstrate that progressive and consistent changes in th e
46 PDE proteome can be identified in PDE samples derived from patients who subsequently developed
47 EPS. The majority of the proteins identified in EPS patients are consistent with their potential
48 involvement in inflammation, the acute phase response, fibrogenenesis and ECM turnover (Table 2).
49 This novel data supports the need for further investigation using classical measurement techniques.
50 Future studies should focus on the quantitative investigation of the proteins identified here and in other
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2 studies, in large, multicenter, well-stratified PD patient cohorts to provide robust validation of the use of
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4 these proteins as potential predictive and diagnostic tools, either individually or as part of a fingerprint.
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Methods

(Comprehensive description of methods used provided in supplementary material)

Patient Cohorts, Matching and Sample Collection

Patients were drawn from the Global Fluid Study (GFS)⁽⁶⁶⁾ and a smaller single-centre cohort from the University of Patras, Greece. The GFS cohort provided prospectively collected effluent samples from patients with confirmed diagnosis of EPS and control patients primarily matched for treatment exposure (time on PD or time to EPS/stopping PD) and centre (Supplemental tables 1&2). The Greek cohort provided single, large volume samples from nine selected patients, needed for the optimization of Proteominer™ for use with PDE. The study was conducted adhering to the tenets of the Declaration of Helsinki and informed consent was obtained from all patients. Ethical approval was obtained from the Multi-Centre Research Ethics Committee for Wales covering the UK, whilst local country ethics were obtained for other contributing countries. The clinical and demographic characteristics of participating patients from both cohorts are summarised in Table 3a and 3b, respectively.

Sample preparation

Total protein was precipitated using acetone/100%TCA, and resolubilised in buffer. 60µg of protein were loaded on pH 4-7 immobilised pH gradient (IPG) strips (Bio-Rad Laboratories Ltd., Hercules, CA, U.S.A.).

Two-dimensional electrophoresis

Isoelectric focusing (IEF) was performed in a PROTEAN IEF system using a four-step protocol and subsequently, proteins were fractionated on a 20 x 23cm 10% polyacrylamide gel using a PROTEAN Plus Dodeca Cell system (Bio-Rad Laboratories Ltd., Hercules, CA, U.S.A.).

Gel fixing and silver staining

Gels were fixed using 40% methanol and 10% acetic acid and silver-stained as described elsewhere.⁽⁶⁷⁾

Gel Imaging

Gels were scanned on a Genetools densitometer (transmission) and PDQuest v8.0 (Bio-Rad Laboratories Ltd., Hercules, CA, U.S.A.) was used for image analysis.

Proteome mining

Proteominer™ (Biorad, Laboratories Ltd., Hercules, CA, U.S.A.) was employed, using a 20µl of beads to 10 mg of protein ratio and a two-step elution protocol.⁽⁶⁸⁾

iTRAQ labeling

Sample labeling with iTRAQ reagents was performed as described elsewhere.⁽⁶⁹⁾ Briefly, 100 µg of protein from each sample was reduced, alkylated and digested with trypsin, prior to labeling (iTRAQ® Reagents – 8plex, AB Sciex™, Framingham, MA, USA).

Strong Cation Exchange (SCX) Fractionation of Peptides

Briefly, SCX was carried out using a PolySULFOETHYL™ A Column (PolyLC, Columbia, MD) 5µm particle size of 200mm length × 2.1mm id, 200 Å pore size, on a BioLC HPLC unit (Dionex, Surrey, UK). The chromatogram was monitored through a UV Detector (Dionex/LC Packings, Amsterdam, the Netherlands), at 214 nm.

Mass Spectrometry (MS)

Mass spectrometry was performed using a Q-Star XL Hybrid ESI Quadrupole time-of-flight tandem mass spectrometer, ESI-qQ-TOF-MS/MS (Applied Biosystems; MDS-Sciex) coupled to an online capillary liquid chromatography system (U3000, Thermo, Hemel Hempstead, UK). Peptides were separated on a PepMap C-18 RP capillary column (LC Packings).

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MS Data Analysis

Peak list conversion was performed using the mascot.dll embedded script (V1.6) coupled with Analyst QS 1.1.1 (ABSCIEX, Framingham, MA, USA). Protein identification and relative quantification was carried out in Phenyx v2.6 (GeneBio S.A., Geneva, Switzerland), using a human protein database. False discovery rate (FDR) was calculated using a decoy database automatically created by reversing the sequences from the target database⁽⁷⁰⁾ and was found to be 1%. Figures show exemplar data and samples for iTRAQ were pooled and thus do not include standard errors. For Figure 7, multiple samples from 2D-gels run concurrently have been combined to provide a mean and therefore the standard errors were calculated..

Disclosures

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References:

1. Kawaguchi Y, Kawanishi H, Mujais S et al. Encapsulating peritoneal sclerosis: definition, etiology, diagnosis, and treatment. International Society for Peritoneal Dialysis Ad Hoc Committee on Ultrafiltration Management in Peritoneal Dialysis. *Perit Dial Int*. 2000;20 (Suppl 4): S43-65.
2. Afthentopoulos IE, Passadakis P, Oreopoulos DG et al. Sclerosing peritonitis in continuous ambulatory peritoneal dialysis patients: one center's experience and review of the literature *Adv Ren Replace Ther*. 1998 Jul;5(3):157-67.
Erratum in
• *Adv Ren Replace Ther* 1998 Oct;5(4):353.
3. Summers AM, Clancy MJ, Syed F et al. Single-center experience of encapsulating peritoneal sclerosis in patients on peritoneal dialysis for end-stage renal failure. *Kidney Int*. 2005 Nov;68(5):2381-8.
4. Kawanishi H, Kawaguchi Y, Fukui H et al. Encapsulating peritoneal sclerosis in Japan: a prospective, controlled, multicenter study. *Am J Kidney Dis*. 2004 Oct;44(4):729-37.
5. Brown MC, Simpson K, Kerssens JJ, et al. Encapsulating peritoneal sclerosis in the new millennium: a national cohort study. *Clin J Am Soc Nephrol*. 2009 Jul;4(7):1222-9. doi: 10.2215/CJN.01260209. Epub 2009 Jun 18.
6. Rigby RJ, Hawley CM. Sclerosing peritonitis: the experience in Australia. *Nephrol Dial Transplant*. 1998 Jan;13(1):154-9.
7. Johnson DW, Cho Y, Livingston BE, et al. Encapsulating peritoneal sclerosis: incidence, predictors, and outcomes. *Kidney Int*. 2010 May;77(10):904-12. doi: 10.1038/ki.2010.16. Epub 2010 Mar 10.
8. Korte MR, Sampimon DE, Lingsma HF, et al. Risk factors associated with encapsulating peritoneal sclerosis in Dutch EPS study. *Perit Dial Int*. 2011 May-Jun;31(3):269-78. doi: 10.3747/pdi.2010.00167. Epub 2011 Mar 31.
9. Morelle J, Sow A, Hautem N et al. Interstitial Fibrosis Restricts Osmotic Water Transport in Encapsulating Peritoneal Sclerosis. *J Am Soc Nephrol*. 2015 Oct;26(10):2521-33. doi: 10.1681/ASN.2014090939. Epub 2015 Jan 30.
10. Sampimon DE, Korte MR, Barreto DL, et al. Early diagnostic markers for encapsulating peritoneal sclerosis: a case-control study. *Perit Dial Int*. 2010 Mar-Apr;30(2):163-9. doi: 10.3747/pdi.2009.00022. Epub 2010 Feb 1.
11. Lambie ML, John B, Mushahar L, et al. The peritoneal osmotic conductance is low well before the diagnosis of encapsulating peritoneal sclerosis is made. *Kidney Int*. 2010 Sep;78(6):611-8. doi: 10.1038/ki.2010.186. Epub 2010 Jun 23.
12. Balasubramaniam G, Brown EA, Davenport A, et al. The Pan-Thames EPS study: treatment and

- outcomes of encapsulating peritoneal sclerosis. *Nephrol Dial Transplant*. 2009 Oct;24(10):3209-15. doi: 10.1093/ndt/gfp008. Epub 2009 Feb 11.
13. Yamamoto R, Otsuka Y, Nakayama M, et al. Risk factors for encapsulating peritoneal sclerosis in patients who have experienced peritoneal dialysis treatment. *Clin Exp Nephrol*. 2005 Jun;9(2):148-52.
14. Summers AM, Brenchley PE. An international encapsulating peritoneal sclerosis registry and DNA bank: why we need one now. *Perit Dial Int*. 2006 Sep-Oct;26(5):559-63.
15. Honda K, Oda H. Pathology of encapsulating peritoneal sclerosis. *Perit Dial Int*. 2005 Apr;25 Suppl 4:S19-29.
16. Yañez-Mo M, Lara-Pezzi E, Selgas R, et al. Peritoneal dialysis and epithelial-to-mesenchymal transition of mesothelial cells. *N Engl J Med*. 2003 Jan 30;348(5):403-13.
17. Margetts PJ, Bonniaud P, Liu L, et al. Transient overexpression of TGF- β 1 induces epithelial mesenchymal transition in the rodent peritoneum. *J Am Soc Nephrol*. 2005 Feb;16(2):425-36. Epub 2004 Dec 8.
18. Patel P, Sekiguchi Y, Oh KH, et al. Smad3-dependent and -independent pathways are involved in peritoneal membrane injury. *Kidney Int*. 2010 Feb;77(4):319-28. doi: 10.1038/ki.2009.436. Epub 2009 Dec 2.
19. Io H, Hamada C, Ro Y, et al. Morphologic changes of peritoneum and expression of VEGF in encapsulated peritoneal sclerosis rat models. *Kidney Int*. 2004 May;65(5):1927-36.
20. Braun N, Reimold F, Biegger D, et al. Fibrogenic growth factors in encapsulating peritoneal sclerosis. *Nephron Clin Pract*. 2009;113(2):c88-95. doi: 10.1159/000228540. Epub 2009 Jul 14.
21. Tarzi RM, Lim A, Moser S, et al. Assessing the validity of an abdominal CT scoring system in the diagnosis of encapsulating peritoneal sclerosis. *Clin J Am Soc Nephrol*. 2008 Nov;3(6):1702-10. doi: 10.2215/CJN.01820408. Epub 2008 Jul 30.
22. Bruschi M, Candiano G, Santucci L, et al. Combinatorial Peptide Ligand Library and two dimensional electrophoresis: new frontiers in the study of peritoneal dialysis effluent in pediatric patients. *J Proteomics*. 2015 Feb 26;116:68-80. doi: 10.1016/j.jprot.2015.01.003. Epub 2015 Jan 10.
23. Oliveira E, Araújo JE, Gómez-Meire S, et al. Proteomics analysis of the peritoneal dialysate effluent reveals the presence of calcium-regulation proteins and acute inflammatory response. *Clin Proteomics*. 2014 Apr 17;11(1):17. doi: 10.1186/1559-0275-11-17. e-Collection 2014.
24. Wen Q, Zhang L, Mao HP, et al. Proteomic analysis in peritoneal dialysis patients with different peritoneal transport characteristics. *Biochem Biophys Res Commun*. 2013 Aug 30;438(3):473-8. doi: 10.1016/j.bbrc.2013.07.116. Epub 2013 Aug 2.
25. Yang MH, Wang HY, Lu CY, et al. Proteomic profiling for peritoneal dialysate: differential protein expression in diabetes mellitus. *Biomed Res Int*. 2013;2013:642964. doi: 10.1155/2013/642964. Epub 2013 May 28.

26. Wu HY, Liao AC, Huang CC, et al. Comparative proteomic analysis of peritoneal dialysate from chronic glomerulonephritis patients. *Biomed Res Int*. 2013;2013:863860. doi: 10.1155/2013/863860. Epub 2013 May 14.
27. Zhang L, Wen Q, Mao HP, et al. Developing a reproducible method for the high-resolution separation of peritoneal dialysate proteins on 2-D gels. *Protein Expr Purif*. 2013 Jun;89(2):196-202. doi: 10.1016/j.pep.2013.03.010. Epub 2013 Apr 2.
28. Tyan YC, Su SB, Ting SS, et al. A comparative proteomic analysis of peritoneal dialysate before and after the occurrence of peritonitis episode by mass spectrometry. *Clin Chim Acta*. 2013 May;420:34-44. doi: 10.1016/j.cca.2012.10.010. Epub 2012 Oct 15.
29. Wang HY, Lin CY, Chien CC, et al. Impact of uremic environment on peritoneum: a proteomic view. *J Proteomics*. 2012 Apr 3;75(7):2053-63. doi: 10.1016/j.jprot.2012.01.011. Epub 2012 Jan 16.
30. Pešić I, Dihazi GH, Müller GA, et al. Short-term increase of glucose concentration in PDS results in extensive removal and high glycation level of vital proteins during continuous ambulatory peritoneal dialysis. *Nephrol Dial Transplant*. 2011 Aug;26(8):2674-83. doi: 10.1093/ndt/gfq793. Epub 2011 Feb 1.
31. Cuccurullo M, Evangelista C, Vilasi A, et al. Proteomic analysis of peritoneal fluid of patients treated by peritoneal dialysis: effect of glucose concentration. *Nephrol Dial Transplant*. 2011 Jun;26(6):1990-9. doi: 10.1093/ndt/gfq670. Epub 2010 Nov 15.
32. Lechner M, Kratochwill K, Lichtenauer A, et al. A proteomic view on the role of glucose in peritoneal dialysis. *J Proteome Res*. 2010 May 7;9(5):2472-9. doi: 10.1021/pr9011574.
33. Wang HY, Tian YF, Chien CC, et al. Differential proteomic characterization between normal peritoneal fluid and diabetic peritoneal dialysate. *Nephrol Dial Transplant*. 2010 Jun;25(6):1955-63. doi: 10.1093/ndt/gfp696. Epub 2010 Jan 6.
34. Lin WT, Tsai CC, Chen CY, et al. Proteomic analysis of peritoneal dialysate fluid in patients with dialysis-related peritonitis. *Ren Fail*. 2008;30(8):772-7. doi: 10.1080/08860220802248969.
35. Dihazi H, Müller CA, Mattes H, et al. Proteomic analysis to improve adequacy of hemo- and peritoneal dialysis: Removal of small and high molecular weight proteins with high- and low-flux filters or a peritoneal membrane. *Proteomics Clin Appl*. 2008 Jul;2(7-8):1167-82. doi: 10.1002/prca.200780143. Epub 2008 Jul 10.
36. Raaijmakers R, Pluk W, Schröder CH, et al. Proteomic profiling and identification in peritoneal fluid of children treated by peritoneal dialysis. *Nephrol Dial Transplant*. 2008 Jul;23(7):2402-5. doi: 10.1093/ndt/gfn212. Epub 2008 Apr 19.
37. Sritippayawan S, Chiangjong W, Semangoen T, et al. Proteomic analysis of peritoneal dialysate fluid in patients with different types of peritoneal membranes. *J Proteome Res*. 2007 Nov;6(11):4356-62. Epub 2007 Oct 9.
38. Brewis IA, Topley N. Proteomics and peritoneal dialysis: early days but clear potential. *Nephrol Dial Transplant*. 2010 Jun;25(6):1749-53. doi: 10.1093/ndt/gfq145. Epub 2010 Mar 26.
39. Williams JD, Craig KJ, Topley N, et al. Morphologic changes in the peritoneal membrane of patients with renal disease. *J Am Soc Nephrol*. 2002 Feb;13(2):470-9.

1
2 40. Mateijsen MA, van der Wal AC, Hendriks PM, et al. Vascular and interstitial changes in the
3 peritoneum of CAPD patients with peritoneal sclerosis. *Perit Dial Int*. 1999 Nov-Dec;19(6):517-25.
4
5
6 41. Osada S, Hamada C, Shimaoka T, et al. Alterations in proteoglycan components and
7 histopathology of the peritoneum in uraemic and peritoneal dialysis (PD) patients. *Nephrol Dial*
8 *Transplant*. 2009 Nov;24(11):3504-12. doi: 10.1093/ndt/gfp268
9
10 42. Fielding CA, Jones GW, McLoughlin RM, et al. IL-6 Signaling Drives Fibrosis in Unresolved
11 Inflammation. *Immunity* 2014; 40; 40-50. (doi 10.1016/j.immuni.2013.10.022)
12
13 43. Reimold FR, Braun N, Zsengeller ZK, et al. Transcriptional patterns in peritoneal tissue of
14 encapsulating peritoneal sclerosis, a complication of chronic peritoneal dialysis. *PLoS One*.
15 2013;8(2):e56389. doi: 10.1371/journal.pone.0056389. Epub 2013 Feb 13.
16
17 44. Guo H, Leung JC, Lam MF, et al. Smad7 transgene attenuates peritoneal fibrosis in uremic rats
18 treated with peritoneal dialysis. *J Am Soc Nephrol*. 2007 Oct;18(10):2689-703. Epub 2007 Sep 12.
19
20 45. Haynes J, Srivastava J, Madson N, et al. Dynamic actin remodeling during epithelial-to-
21 mesenchymal transition depends on increased moesin expression. *Mol Biol Cell*. 2011
22 Dec;22(24):4750-64. doi: 10.1091/mbc.E11-02-0119. Epub 2011 Oct 26.
23
24 46. Mejean C, Roustan C, Benyamin Y. Anti-actin antibodies. Detection and quantitation of total and
25 skeletal muscle actin in human plasma using a competitive ELISA. *J Immunol Methods*. 1987 May
26 4;99(1):129-35.
27
28 47. Mariano F, Tetta C, Montrucchio G, et al. Role of alpha 1-proteinase inhibitor in restraining
29 peritoneal inflammation in CAPD patients. *Kidney Int*. 1992 Sep;42(3):735-42.
30
31 48. Recalde D, Ostos MA, Badell E, et al. Human apolipoprotein A-IV reduces secretion of
32 proinflammatory cytokines and atherosclerotic effects of a chronic infection mimicked by
33 lipopolysaccharide. *Arterioscler Thromb Vasc Biol*. 2004 Apr;24(4):756-61. Epub 2004 Jan 29.
34
35 49. Lambie M, J. Chess J, Summers A, et al. Peritoneal Inflammation Precedes Encapsulating
36 Peritoneal Sclerosis: Results from the GLOBAL Fluid Study. *Nephrol Dial Transplant*. 2016
37 Mar;31(3):480-6
38
39 50. Fournier T, Medjoubi-N N, Porquet D. Alpha-1-acid glycoprotein. *Biochim Biophys Acta*. 2000 Oct
40 18;1482(1-2):157-71.
41
42 51. Hochepped T, Berger FG, Baumann H, et al. Alpha(1)-acid glycoprotein: an acute phase protein
43 with inflammatory and immunomodulating properties. *Cytokine Growth Factor Rev*. 2003
44 Feb;14(1):25-34.
45
46 52. Bohenek WS, Johnson CA, Ateshkadi A, et al. Effect of peritonitis on plasma and dialysate alpha
47 1-acid glycoprotein concentrations in peritoneal dialysis patients. *Clin Pharm*. 1993 Aug;12(8):602-5.
48
49 53. Li W, Zhu S, Li J, et al. A hepatic protein, fetuin-A, occupies a protective role in lethal systemic
50 inflammation. *PLoS One* 2011 Feb 8;6(2):e16945. doi: 10.1371/journal.pone.0016945.
51
52
53
54
55
56
57
58
59
60

54. Tuttolomondo A, Di Raimondo D, Di Sciacca R, et al. Fetuin-A and CD40 L plasma levels in acute ischemic stroke: differences in relation to TOAST subtype and correlation with clinical and laboratory variables. *Atherosclerosis*. 2010 Jan;208(1):290-6. doi: 10.1016/j.atherosclerosis.2009.07.032. Epub 2009 Jul 23.
55. Demetriou M, Binkert C, Sukhu B, et al. Fetuin/alpha2-HS glycoprotein is a transforming growth factor-beta type II receptor mimic and cytokine antagonist. *J Biol Chem*. 1996 May 31;271(22):12755-61.
56. van Campenhout A, van Campenhout CM, Lagrou AR, et al. Transferrin modifications and lipid peroxidation: implications in diabetes mellitus. *Free Radic Res*. 2003 Oct;37(10):1069-77.
57. Tombini M, Squitti R, Cacciapaglia F, et al. Inflammation and iron metabolism in adult patients with epilepsy: Does a link exist? *Epilepsy Res*. 2013 Dec;107(3):244-52. doi: 10.1016/j.epilepsyres.2013.09.010. Epub 2013 Sep 28.
58. Hortin GL, Sviridov D, Anderson NL. High-abundance polypeptides of the human plasma proteome comprising the top 4 logs of polypeptide abundance. *Clin Chem*. 2008 Oct;54(10):1608-16. doi: 10.1373/clinchem.2008.108175. Epub 2008 Aug 7.
59. Hortin GL, Sviridov D. The dynamic range problem in the analysis of the plasma proteome. *J Proteomics*. 2010 Jan 3;73(3):629-36. doi: 10.1016/j.jprot.2009.07.001. Epub 2009 Jul 17.
60. Hartwig S, Lehr S. Combination of highly efficient hexapeptide ligand library-based sample preparation with 2D DIGE for the analysis of the hidden human serum/plasma proteome. *Methods Mol Biol*. 2012;854:169-80. doi: 10.1007/978-1-61779-573-2_12.
61. Schaffler A, Neumeier M, Herfarth H, et al. Genomic structure of human omentin, a new adipocytokine expressed in omental adipose tissue. *Biochim Biophys Acta*. 2005 Dec 30;1732(1-3):96-102. Epub 2005 Dec 19.
62. Okamoto O, Fujiwara S, Abe M, et al. Dermatotontin interacts with transforming growth factor beta and enhances its biological activity. *Biochem J*. 1999 Feb 1;337 (Pt 3):537-41.
63. Gambichler T, Skrygan M, Czempel V, et al. Differential expression of connective tissue growth factor and extracellular matrix proteins in lichen sclerosus. *J Eur Acad Dermatol Venereol*. 2012 Feb;26(2):207-12. doi: 10.1111/j.1468-3083.2011.04037.x. Epub 2011 Mar 24.
64. Goodlad C, Tam FW, Ahmad S, et al. Dialysate cytokine levels do not predict encapsulating peritoneal sclerosis. *Perit Dial Int*. 2014 Sep-Oct;34(6):594-604. doi: 10.3747/pdi.2012.00305.
65. Lopes Barreto D, Struijk DG, Krediet RT. Peritoneal effluent MMP-2 and PAI-1 in encapsulating peritoneal sclerosis. *Am J Kidney Dis*. 2015 May;65(5):748-53. doi: 10.1053/j.ajkd.2014.10.022.
66. Lambie M, Chess J, Donovan KL, et al. Independent effects of systemic and local peritoneal inflammation on membrane function and survival of PD patients: results from the GLOBAL Fluid Study. *J Am Soc Nephrol* 2013; 24: 2071–2080 (doi: 10.1681/ASN.2013030314)

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56
57
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59
60

67. Blum,H., Beier,H. and Gross,H.J. Improved silver staining of plant proteins, RNA and DNA in polyacrylamide gels. *Electrophoresis* (1987) 8, 93-99

68. Candiano G, Dimuccio V, Bruschi M, et al. Combinatorial peptide ligand libraries for urine proteome analysis: investigation of different elution systems. *Electrophoresis* 2009 Jul;30(14):2405-11. doi: 10.1002/elps.200800762.

69. Pham TK, Roy S, Noirel J, et al. A quantitative proteomic analysis of biofilm adaptation by the periodontal pathogen *Tannerella forsythia*. *Proteomics*. 2010 Sep;10(17):3130-41. doi: 10.1002/pmic.200900448.

70. Ow SY, Cardona T, Taton A, et al. Quantitative shotgun proteomics of enriched heterocysts from *Nostoc* sp. PCC 7120 using 8-plex isobaric peptide tags. *J Proteome Res*. 2008 Apr;7(4):1615-28. doi: 10.1021/pr700604v. Epub 2008 Feb 22.

71. Elias JE, Gygi SP. Target-decoy search strategy for increased confidence in large-scale protein identifications by mass spectrometry. *Nat Methods*. 2007 Mar;4(3):207-14.

Legends:

Figure 1: Exemplar images showing the changes in the PD fluid proteome over 4 years on dialysis in a patient with stable membrane function using 2D PAGE

10 PDE samples spanning days 9 to 1410 of peritoneal dialysis of approximately 2 ml volume were precipitated with 3.5 volume of acetone/10% TCA and the pellet was re-solubilised in buffer. A volume equivalent to 60µg of protein was subjected to isoelectric focusing on a pH 4-7 IPG strip (Bio-Rad) using passive rehydration with proteins further separated on a Bio-Rad Dodeca gel system and fractionated overnight. Each gel was recovered and silver stained using the Blum method. Gels were scanned on a Genetools densitometer (transmission), entered into PDQuest software and spot patterns compared. Exemplar images from GFS patient G01-029 (stable membrane function).

Figure 2: Fibrinogen γ-chain (a) and Heparan sulphate proteoglycan (b) are elevated in PD fluid with time on PD in a patient with stable membrane function (exemplar images).

Exemplar images from patient G05-068 (stable membrane function). 10 PD fluid samples were available, ranging from day 30 through to day 3013 on PD that were analysed for spot changes as in figure 1. Protein spots 6001 (a) and 6003 (b) were identified as changing with time on PD by PDQUEST software based on spot volume density. These were excised from the gel and subjected to MALDI-TOF Mass spectrometry. The proteins were identified as fibrinogen γ-chain (a) and heparan sulphate proteoglycan (HSPG) (b). Graphs show a single spot volume density at all 10 timepoints from 1 x 10 gel run. Fibrinogen γ chain gel images depict changes occurring between 2 ½ & 5 years where as HSPG shows images up to 3 years.

Figure 3: Collagen a(1)I (a) and γ-actin (b) are elevated in a patient with EPS 5 years before EPS diagnosis (exemplar images)

Exemplar images from GFS patients G05-072 (confirmed EPS) and G05-068 (stable membrane

function). 5 PD fluid samples were available from patient G05-072, spanning days 1043 to 2868 of PD. These were matched to 5 samples from patient G05-068, based on time from start of PD and comparative 2D SDS-PAGE proteomics undertaken as in figure 1. Two spots as identified with a black arrow in both panels were seen to be consistently elevated in all EPS patients at all time points which was confirmed by volume densitometric analysis. This protein spots were excised from the gel and subjected to MALDI-TOF mass spectrometry. The proteins were identified as a fragment of collagen $\alpha 1(I)$ (a) and as γ -actin (b). Of note, the spot identified by a white arrow in panel (a) at 55kDa was only elevated in this single EPS patient. Graphs show a single spot volume density at all 5 time points from 1 x 10 gel run with the first 5 bars being the identified spot in the EPS sample and the second 5 bars the stable patient plotted in chronological area.

Figure 4: Complement factors I and B increase in EPS 5 years before diagnosis (exemplar images).

Exemplar images from GFS patients G05-072 (confirmed EPS) and G05-068 (stable membrane function). 5 PD fluid samples were available from patient G05-072, spanning days 1043 to 2868 of PD. These were matched to 5 samples from patient G05-068 based on time from start of PD and comparative 2D SDS-PAGE proteomics performed as figure 1. Two spots that were elevated by volume densitometry in EPS in this and 3 out of 4 other patient comparison runs were identified as complement factor I (black arrow) and complement factor B (white arrow).

Figure 5: iTRAQ identifies 4 proteins with altered levels in an EPS patient compared to a matched control.

Four PD samples from patient G05-072 (confirmed EPS) were matched with 4 PD samples from patient G05-068 (stable membrane function), by time to finishing dialysis. Each sample was precipitated in 3 volumes of acetone/10% TCA, re-dissolved & then buffer exchanged into triethylammonium bicarbonate (TEAB). 50 μ g of protein was denatured in tris-(2-

carboxyethyl)phosphine and reduced in methylmethane-thiosulfonate prior to trypsin digestion. Each sample was then labelled with a different isobariq tag using the 8 label iTRAQ system. All samples were mixed, fractionated by RP-HPLC and proteins identified by MODI-TOF MS. For each of 72 proteins detected, the ratio of each protein was calculated based on the abundance of each isobariq tag within that protein sample. Using this approach 4 proteins showed consistent trends. Orosomucoid-1 and α 2-HS-glycoprotein chain B were both elevated in the EPS patient some 12 months before diagnosis, while Apolipoprotein A-IV was always low in EPS with a dramatic late drop in serotransferrin. Data shown represents fold change in the confirmed EPS patient compared to the patient with stable membrane function and is from a single experimental run.

Figure 6: ProteoMiner allows detection of lower abundance proteins in PD fluid

A PD fluid volume equivalent to 15mg of protein was reduced to 500 μ l volume using a 3kDa molecular weight cut off concentrator. 10mg of protein was then subjected to the low abundance protein enrichment using the Bio-Rad ProteoMiner™ system using 20 μ l of beads. 100 μ g of eluted protein and that from the original PD fluid samples was precipitated using 3 volume acetone/10% TCA and comparative analysis performed using 2D SDS PAGE proteomic analysis as in figure 1. The total number of resolved protein spots was calculated using PDQUEST.

Figure 7: In protein mined PD fluid Intelectin-1 (a) and dermatopontin (b) are elevated in EPS.

From a Greek cohort of PD fluid samples (University of Patras), fluid was taken from 3 patients with suspected EPS (2 of them confirmed post-portem), 3 patients who had remained on PD for more than 5 years but had no signs of EPS (late controls) and 3 patients with samples taken within the first month of starting PD (early controls). A volume equivalent to 15mg of protein was concentrated and subjected to ProteoMiner™ enrichment as in figure 6. Samples were then subjected to 2D SDS-PAGE analysis as in figure 1, with spots identified as different between the EPS (column 1), late controls (column 2) and early controls (column 3) identified using PDQUEST. Spot 7203 (a) was

1 identified as being elevated in all 3 patients with EPS, which was confirmed by subsequent volume
2 densitometry measurement of the spot in all 9 samples. Spot 1001 (b) was identified as being
3 elevated in all 3 patients with EPS and one of the late controls, which was confirmed by subsequent
4 volume densitometry measurement of the spot in all 9 samples. These spots were subsequently
5 excised from the gel and identified by MALDI-TOF as intelectin-1 (a) and Dermato pontin (b). Spot
6 volume densitometry from all 3 patients in each group was averaged with data presented as
7 mean±SEM in the 2 bar graphs. Significance was determined by 1 way ANOVA, * p<0.05, ** p<0.01
8 compared to early PD control group.
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21 **Figure 8: Analysis of pooled samples at four matched time-points using iTRAQ after treatment**
22 **with Proteominer.**
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24 Patient samples were pooled into 4 groups based on time (>24 mths, 12-24 mths, 6-12 mths , <6
25 mths) to developing EPS or stopping PD. Each pool consisted of equal amounts of protein from each
26 sample available. Post pooling they were processed using ProteoMiner™, iTRAQ labelled,
27 fractionated by RP HPLC and then subjected to tandem MS.
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36 **Figure 9: Hierarchical Cluster analysis (a) and heatmap (b) of proteins detected from proteome-**
37 **mined pooled EPS PD effluent iTRAQ analysis.**
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39 The relative contribution of each pooled cohort to the total level of each protein identified was made
40 based on the abundance of each isobariq tag. The proteins detected in each cohort were then used to
41 position each as a hierarchical cluster. E=EPS, N=Normal (stable PD), E1/N1 = >24 mths, E2/N2 = 12-
42 24, E3/N3 = 6-12 mths and E4/N4= <6Mths to EPS or stopping PD (a). The variation in each protein
43 detected in each cohort was then plotted as a heat map (b). Arrows indicate Intellectin-1 and Gelsolin.
44 Data is from a single run.
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56 **Figure 10: Relative changes in proteins showing progressive variation with time in pooled**
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cohorts of EPS patients subjected to protein mining and iTRAQ analysis.

Relative levels of intelectin-1, Gelsolin, Apolipoprotein A-II and Hemoglobin beta subunit were determined by calculating the ratio to the >24-month cohort level in the patients not developing EPS. Data represents ratio to >24month stable patient from a single run of pooled samples.

Table 1: Proteins detectable by iTRAQ in PD fluid

Total proteins identified in PD fluid samples by iTRAQ. Identification is based on at least 3 different identifiable sequences within a protein.

Table 2: Top potential hits for EPS bio markers from 2D PAGE & iTRAQ proteomics

From all 2D SDS-PAGE proteomics using mined and un-mined samples plus iTRAQ studies, proteins that were significantly altered in at least 75% of patients with EPS and less than 10% of non-EPS patients were short-listed as those most likely to have value as prognostic or diagnostic markers of EPS. For 2D gels data shows number of patients showing the change out of total evaluated.

Table 3: Patient Demographics for (a) the GFS and (b) the University of Patras cohorts.

Figures are given as mean (SD), median (range) and percentages as appropriate. For iTRAQ analysis of protein mined samples (a), GFS effluent samples were pooled into 4 groups based on time to developing EPS or stopping PD: Group 1; < 6 months prior to EPS or stopping dialysis, Group 2; 6-12 months prior to stopping dialysis, Group 3; 12 to 24 months prior to stopping dialysis and Group 4; greater than 24 months before cessation of dialysis (see also figure 8). Each group consisted of 5 to 7 patient samples.

Comorbidity was documented using the validated Stoke Comorbidity Index, which both categorizes patients into low-risk (score 0), intermediate-risk (score 1–2), and high-risk (score >2) groups and enables analysis by individual comorbid conditions within the index⁽³⁹⁾.

For the ProteoMiner™ experiments, a single peritoneal fluid sample was obtained from each of nine

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selected patients from a cohort of Greek PD patients (**b**).

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Patients and Methods

Patient Cohorts, Matching and Sample Collection

Patients were drawn from two cohorts, the Global Fluid Study (GFS), an international, multi-centre, prospective, observational cohort study seeking to relate peritoneal membrane function to local and systemic biomarkers as predictors of predefined clinical endpoints (e.g. patient survival, membrane injury)⁽⁶⁶⁾, and a smaller single-centre cohort of Greek patients. GFS recruited incident (within first 90 days of PD) and prevalent patients from 10 participating centres from the UK, Korea and Canada between June 2002 and December 2008. Dialysate sampling was from a 4-hour peritoneal equilibration test (PET) using a 2.27% glucose bag, with simultaneous clinical data collected and stored in a purpose built Peritoneal Dialysis Access database (PDDb). The study was conducted adhering to the tenets of the Declaration of Helsinki and informed consent was obtained from all patients. Ethical approval was obtained from the Multi-Centre Research Ethics Committee for Wales covering the UK, whilst local country ethics were obtained for other contributing countries.

For this analysis, EPS patients were identified according to ISPD guidelines⁽¹⁾ in 5 UK centres. For 2D gel proteomics, Global patients were matched primarily on the duration of PD and centre, which in some comparisons required 2 control patients. Closer matching was not possible due to the limited number of patients having prolonged exposure to PD. For ITRAQ proteomics, Global patients were matched based on time to EPS. For pooled studies, 10 EPS patients and 18 with stable membrane function were divided into 4 time segments of <6 months, 6 to 12 months, 12 to 24 months and >24 months from EPS or stopping PD (supplemental table 1). Each pool consisted of between 5 and 7 samples which together made up a minimum amount of 18.8mg of starting protein. This protein pool was made up using equivalent protein amounts from all patients contributing to the pool. The

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demographic and clinical characteristics of these patients and their controls, including the number of samples analysed and their temporal matching is summarized in Table 3a.

To optimise ProteoMiner™ for use with PDE, experiments requiring larger dialysate volumes, samples from a smaller PD effluent repository based at the University Hospital of Patras, Greece were used. This repository was created in 2009 with the aim to collect samples of peritoneal tissue and PDE, to study potential correlations between effluent markers of inflammation and fibrosis and biopsy findings at catheter placement and removal. The project, was approved by the Ethics Committee of the University Hospital of Patras and informed consent was obtained from incident (scheduled for peritoneal catheter placement) and prevalent patients receiving PD treatment in the same centre. 100ml PDE samples from overnight (8-hour) dwells (Physioneal® 40 Glucose 1.36% w/v, Baxter Healthcare Ltd.) were collected at recruitment (within the first month from PD start for incident patients) and at 6-month intervals thereafter. Samples were also obtained at PD stop, due to kidney transplant or transfer to hemodialysis. At each sampling visit, clinical and demographic data were collected and stored in a database. For the present analysis a single sample from each of nine selected patients was analysed. Selected patients included three incident patients, three prevalent patients with >5 years on PD and stable membrane function and three prevalent patients with suspected EPS based on clinical presentation. In two of the latter, EPS diagnosis was confirmed at autopsy. The third patient was lost to follow up after having been transferred to hemodialysis at another institution. The demographic and clinical characteristics of these patients are summarized in Table 3b.

Sample preparation

All samples were stored in -80° C and thawed for aliquoting and just prior to use in experiments. Total protein was precipitated using 3.5 volumes of acetone

chilled at -20°C and 0.5 volumes of 100%TCA for every volume of sample. Subsequently, samples were centrifuged in a Sigma 3-18 centrifuge (Sigma Laborzentrifugen GmbH, Germany) at 4248 RCF for 40 minutes, at a temperature of 10°C . The protein pellet was re-solubilised in 500 μl of buffer containing 8M urea, 2M thiourea, 4% CHAPS, 0.2% (v/v) ampholytes (pH 4–7, 100 mM DTT, 40 mM Tris–base, and 0.0002% bromophenol blue in 18.2M Ωm water. To facilitate re-solubilisation, samples were vortexed for 30 seconds and sonicated in a cold water bath for 15 minutes. Following re-solubilisation, protein concentration was determined using the Thermo Scientific Pierce 660nm Protein Assay (Thermo Fisher Scientific Rockford, IL., U.S.A), according to manufacturer's instructions. A volume corresponding to 60 μg of protein was increased to a final volume of 350 μl by adding solubilisation buffer. This volume was loaded on a pH 4-7 immobilised pH gradient (IPG) strip (Bio-Rad Laboratories Ltd., Hercules, CA, U.S.A.), covered with 3ml of mineral oil and left overnight to allow complete absorption on the strip.

Isoelectric Focusing

Loaded IPG strips were subjected to isoelectric focusing (IEF) using a PROTEAN IEF system (Bio-Rad Laboratories Ltd., Hercules, CA, U.S.A.). Default temperature was set to 20°C . A four-step programme was used as follows: Step 1: 250V over 4.5 hours. Step 2: linear increase up to 10,000V over 2.5 hours. Step 3: instant increase up to 10,000V until 50,000 V*h were completed. Step 4: instant decrease down to 500V until 70,000 V*h were completed.

SDS-PAGE

Following isoelectric focusing, IPG strips were bathed in 2% DTT followed by 2.5% iodoacetamide in equilibration buffer for 15 minutes. Equilibration buffer contained 36% (w/v) urea, 20% glycerol, 2% SDS and 0.005M Tris-HCl (pH 8.8). Proteins were subsequently fractionated on a 20 x 23cm 10% polyacrylamide gel

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containing 0.1% SDS, 2.5% Rhinohide™ (Invitrogen™), 0.05% APS, 0.025% TEMED and 0.375M Tris-HCl. After casting the gels in the casting chamber, 1ml of 50:50 water saturated butan-2-ol was added on top of each gel to remove air bubbles and create a flat surface where the IPG could be applied. 1% overlay agarose (with Bromophenol Blue to observe dye front) secured the IPG. Gels were allowed to set for 2 hours, then washed 3 times with ultra-pure water and finally washed with running buffer (25 mM Tris, 192 mM glycine, 0.1% SDS, pH 8.3) and stored at 4°C until use. For SDS-PAGE a PROTEAN Plus Dodeca Cell system was used (Bio-Rad Laboratories Ltd., Hercules, CA, U.S.A.). Voltage was set to 80V for a minimum of 4 hours and then turned down to 40V until electrophoresis was complete.

Gel fixing and silver staining

After electrophoresis, each gel bathed in fixing solution containing 40% methanol and 10% acetic acid in deionized water for 2 hours. Subsequently gels were washed with 30% ethanol in water, 3 times for 20 minutes each. For silver staining, an optimised protocol based on the method described by Blum et al. was used⁽⁶⁷⁾ First gels bathed in 0.035% sodium thiosulfate for 90 seconds and then were washed with deionized water 3 times, 20 seconds each. Subsequently, 0.2% silver nitrate, 0.02% formaldehyde solution was added for 20 minutes and then gels were washed again 3 times with deionized water, for 20 seconds each. Silver solution was followed by the developer solution containing 3% sodium carbonate, 0.003% sodium thiosulfate pentahydrate and 0.05% formaldehyde. The developer solution was decanted after 5 minutes, provided that visualization of protein spots was clear. Two 30 second washes with water followed before the stop solution containing 0.5% glycine was added for 10 minutes. Finally, the stop solution was decanted and gels were washed with water twice, for 30 minutes each time.

Gel Imaging

Gels were scanned on a Genetools densitometer (transmission). PD Quest v8.0 (Bio-Rad Laboratories Ltd., Hercules, CA, U.S.A.) was used for analysis of the gel images.

Proteome mining

This was undertaken using the Proteominer™ small capacity kit (Biorad, Laboratories Ltd., Hercules, CA, U.S.A.). A volume of sample corresponding to 15mg of protein was centrifuged using a 3kDa cut-off filter until reduced to 500µl. Subsequently, volumes corresponding to 10mg of protein were mined as per manufacturer's instructions using a ratio of 20µl of beads to 10 mg of protein. Elution with 8M urea/2% CHAPS rehydrated with 5% acetic acid, was followed by a second elution using 4% boiling SDS, 25mM DTT to increase recovery⁽⁶⁸⁾ Finally, protein concentration was determined prior to isoelectric focusing or iTRAQ.

iTRAQ

iTRAQ provides a method for simultaneous protein identification and relative quantification in multiplex format. It is a widely used quantitative proteomic strategy in clinical proteomic research, including for biomarker discovery. During iTRAQ analysis, peptides from each sample (post proteolytic digestion preparation step) are labeled with one of the set of reagents, then combined. The iTRAQ reagents are isobaric and thus a labeled peptide set (for a specific amino acid sequence) will have the same mass in all samples at this stage. Peptide identity and the samples in which it is found is determined by tandem mass spectrometry, which selects a specific set of peptides for fragmentation to yield sequence ions and ions for relative quantification. This data provides information on the relative abundance of a particular peptide across all samples within the experiment. Quantification data is based on unique low mass 'reporter ion' (to each iTRAQ label). Reporter ion intensity information is used to calculate fold change relative to a designated control.

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We used an in house statistical analysis pipeline, as detailed in Pham et al. 2010⁽⁶⁹⁾ to i) integrate all the peptide measurement data to the protein level and ii) to determine proteins altered in level between samples (p value <0.05). Sample labeling with iTRAQ reagents was performed as described elsewhere⁽⁷⁰⁾ and as recommended by the manufacturer. One hundred micrograms of protein from each sample (or pool) was reduced, alkylated then digested with trypsin, prior to labeling (iTRAQ® Reagents – 8plex, AB Sciex™, Framingham, MA, USA).

Strong Cation Exchange (SCX) Fractionation of Peptides

The fractionation was performed as described elsewhere⁽⁴¹⁾. Briefly, SCX was carried out using a PolySULFOETHYL™ A Column (PolyLC, Columbia, MD) 5 µm particle size of 200 mm length × 2.1 mm id, 200 Å pore size, on a BioLC HPLC unit (Dionex, Surrey, UK). The 60-min gradient was generated between Buffer A (10 mM KH2PO4 and 25% acetonitrile, pH 3.0), and Buffer B (10 mM KH2PO4, 25% acetonitrile and 500 mM KCl, pH 3.0), and consisted of 100% A for 5 min, 5–30% B for 40 min, 30–100% B for 5 min, 100% B for 5 min and finally 100% A for 5 min. The chromatogram was monitored through a UV Detector (Dionex/LC Packings, Amsterdam, the Netherlands), at 214 nm. Individual SCX fractions were pooled for subsequent nano-LC-MS/MS analysis. Pooled fractions were dried in a vacuum concentrator (Eppendorf, Hamburg, Germany), and stored at –20°C prior to analysis by mass spectrometry.

Mass Spectrometry (MS)

Each peptide fraction was re-dissolved in 20 μ l of 0.1% formic acid and 3% acetonitrile and then 6 μ l of sample was injected into the nano-LC-ESI-MS/MS system for analysis. Mass spectrometry was performed using a Q-Star XL Hybrid ESI Quadrupole time-of-flight tandem mass spectrometer, ESI-qQ-TOF-MS/MS (Applied Biosystems; MDS-Sciex) coupled to an online capillary liquid chromatography system (U3000, Thermo, Hemel Hempstead, UK). Peptides were separated on a PepMap C-18 RP capillary column (LC Packings), with a constant flow rate of 0.3 μ l/min. The LC gradient started with 3% Buffer B (0.1% formic acid in 97% acetonitrile) and 97% Buffer A (0.1% formic acid in 3% acetonitrile) for 3 min, followed by 3–30% Buffer B for 90 min, then 90% Buffer B for 7 min, and finally 3% Buffer B for 8 min. The mass spectrometer was set to perform data acquisition in the positive ion mode, with a selected mass range of 400–1,600 m/z . Peptides with +2 to +4 charge states were selected for tandem mass spectrometry, and the time of summation of MS/MS events was set to 3 sec. The two most abundantly charged peptides above a threshold of five counts were selected for MS/MS, and dynamically excluded for 60 sec with a ± 50 mmu mass tolerance.

MS Data Analysis

Peak list conversion was performed using the mascot.dll embedded script (V1.6) coupled with Analyst QS 1.1.1 (ABSCIEX, Framingham, MA, USA) with MS/MS group summations and the iTRAQ region deisotoping removed. Protein identification and relative quantification was carried out in Phenyx v2.6 (GeneBio S.A., Geneva, Switzerland), using a human protein database. General search parameters allowed for MS and MS/MS tolerance up to 0.1 Da and one missed cleavage. Fixed protein modifications included iTRAQ lysine and iTRAQ N-terminus (+304 Da) and methyl-thiol of cysteines (+46 Da), variable modifications were oxidation of methionine (+16 Da). The acceptance parameters for peptide

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identification were peptide length ≥ 6 , z-score ≥ 5.0 and p-value $\leq 1.0 \times 10^{-4}$. False discovery rate (FDR) was calculated using a decoy database automatically created by reversing the sequences from the target database⁽⁷¹⁾ and was found to be 1%. Bias normalization for whole proteome analyses were also performed by correcting the bias median ratio of each comparison toward unity. Figures show exemplar data and samples for iTRAQ were pooled and thus do not include standard errors. For Figure 7, multiple samples from 2D-gels have been combined to provide a mean and therefore the standard error was calculated.

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Supplemental Table 1: Patient sample matching for 2D gel comparisons

| Patient Code EPS vs Stable PD | Days from starting PD | | | | |
|----------------------------------|-----------------------|--------------|--------------|--------------|--------------|
| | Point 1 | Point 2 | Point 3 | Point 4 | Point 5 |
| G05-072 vs. G05-068 | 1043 vs 1089 | 1448 vs 1490 | 2429 vs 2430 | 2538 vs 2564 | 2868 vs 2013 |
| G05-134 vs G01-029 | 9 vs 9 | 181 vs 203 | 376 vs 203 | 933 vs 870 | - |
| G03-016 vs G03-022 | 772 vs 828 | 870 vs 869 | 1141 vs 1136 | 1297 vs 1213 | - |
| G01 001 vs G01 030 | 1204 vs 1142 | 1567 vs 1497 | 2177 vs 2241 | 2350 vs 2439 | - |
| G01-001 vs G01-15 | 774 vs 785 | 960 vs 953 | 1142 vs 1165 | 1346 vs 1347 | - |
| G05-018 vs G03-006 | 34 vs 90 | 258 vs 294 | 435 vs 447 | 664 vs 665 | - |
| G05-72 vs G0157 | 2009 vs 2170 | 2429 vs 2382 | 2638 vs 2501 | 2868 vs 2737 | - |

EPS and stable PD patient samples were matched at up to 5 time points from the date of starting PD for 2D Gel proteomic analysis. Each comparison shows the day that the sample was collected from the EPS patient versus the day from the stable PD patient

Supplemental table 2: Breakdown of EPS and control sample pooling for iTRAQ analysis on protein mined PDE

| Patient Code | Condition | <6 months | 6-12 Mths | 12-24 Mths | >24 Months | Number of Time points |
|---------------------------------|-----------|-----------|-----------|------------|------------|-----------------------|
| G05-072 | EPS | Y | Y | Y | Y | 4 |
| G05-134 | EPS | Y | | Y | | 2 |
| G03-016 | EPS | Y | | Y | Y | 3 |
| G05-092 | EPS | Y | | | | 1 |
| G05-010 | EPS | Y | Y | | | 2 |
| G01-008 | EPS | | Y | Y | Y | 3 |
| G05-029 | EPS | | Y | | | 1 |
| G05-018 | EPS | | Y | Y | | 2 |
| G01-001 | EPS | | | | Y | 1 |
| G02-052 | EPS | | | | Y | 1 |
| EPS pooled @ each time point | | 5 | 5 | 5 | 5 | |
| G05-042 | Stable PD | Y | | | | 1 |
| G05-002 | Stable PD | Y | | | | 1 |
| G03-006 | Stable PD | Y | | | | 1 |
| G05-093 | Stable PD | Y | Y | | | 2 |
| G03-021 | Stable PD | Y | | Y | | 2 |
| G05-050 | Stable PD | Y | | | | 1 |
| G05-090 | Stable PD | | Y | | | 1 |
| G05-123 | Stable PD | | Y | | | 1 |
| G01-011 | Stable PD | | Y | Y | Y | 3 |
| G05-077 | Stable PD | | Y | | | 1 |
| G05-119 | Stable PD | | | Y | | 1 |
| G05-026 | Stable PD | | | Y | | 1 |
| G03-018 | Stable PD | | | Y | Y | 2 |
| G05-085 | Stable PD | | | Y | | 1 |
| G05-041 | Stable PD | | | | Y | 1 |
| G01-031 | Stable PD | | | | Y | 1 |
| G05-069 | Stable PD | | | | Y | 1 |
| G01-069 | Stable PD | | | | Y | 1 |
| G02-066 | Stable PD | | | | Y | 1 |
| Stable pooled @ each time point | | 6 | 5 | 6 | 7 | |

EPS samples were pooled by time to developing EPS or stopping PD with stable function into cohorts of <6 months, 6-12 months, 12-24 months and .24 months. Each pool contained samples that together gave a minimum of 18.8 mg of protein. All patients (5 to 7) in a pool contributed an equal amount of protein. Some patients contributed to all pools, and some just 1. Y denotes inclusion in the pool. GXX denotes the centre and the following number the patient at that centre.

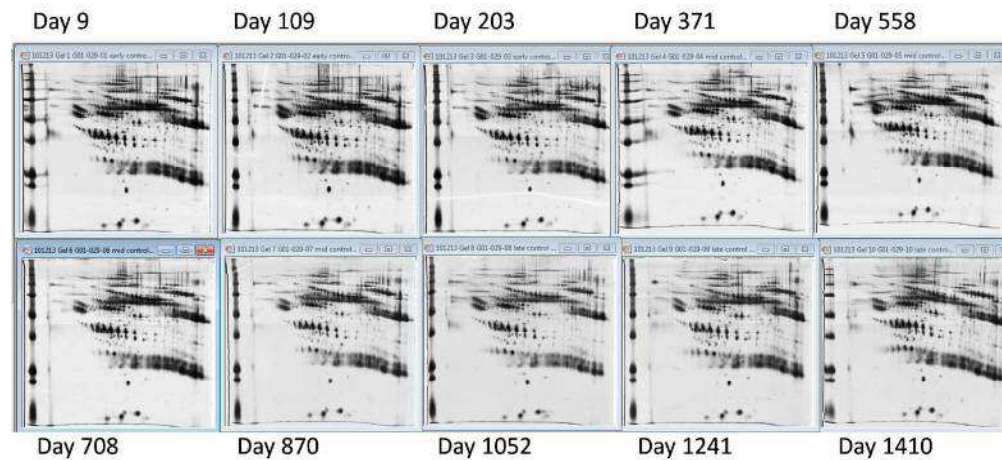


Figure 1: Exemplar images showing the changes in the PD fluid proteome over 4 years on dialysis in a patient with stable membrane function using 2D PAGE

10 PDE samples spanning days 9 to 1410 of peritoneal dialysis of approximately 2 ml volume were precipitated with 3.5 volume of acetone/10% TCA and the pellet was re-solubilised in buffer. A volume equivalent to 60µg of protein was subjected to isoelectric focusing on a pH 4-7 IPG strip (Bio-Rad) using passive rehydration with proteins further separated on a Bio-Rad Dodeca gel system and fractionated overnight. Each gel was recovered and silver stained using the Blum method. Gels were scanned on a Genetools densitometer (transmission), entered into PDQuest software and spot patterns compared. Exemplar images from GFS patient G01-029 (stable membrane function).

Figure 1
1270x952mm (120 x 120 DPI)

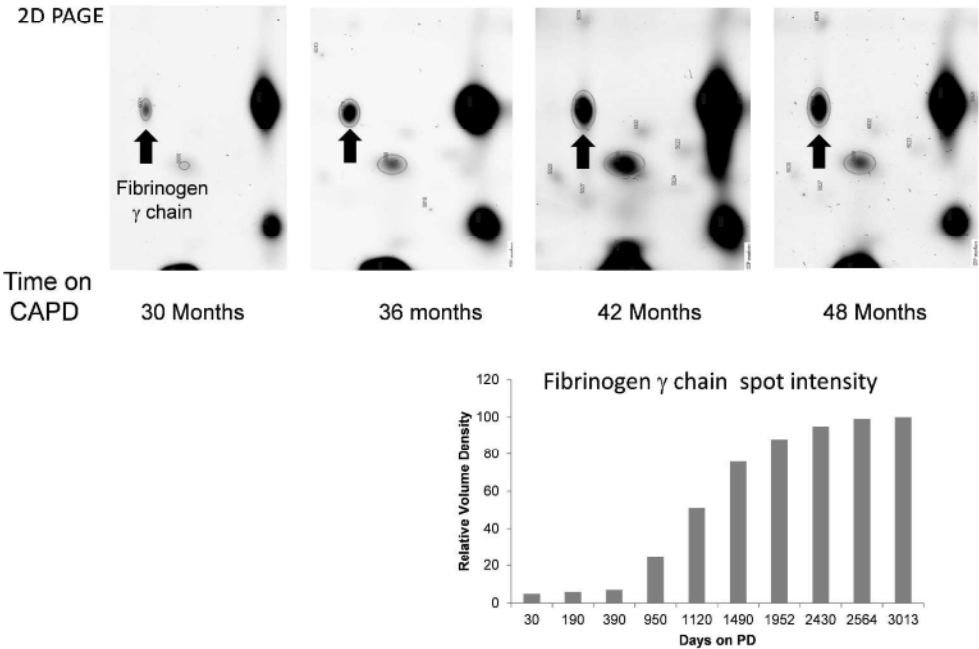


Figure 2: Fibrinogen γ -chain (a) and Heparan sulphate proteoglycan (b) are elevated in PD fluid with time on PD in a patient with stable membrane function (exemplar images).
Exemplar images from patient G05-068 (stable membrane function). 10 PD fluid samples were available, ranging from day 30 through to day 3013 on PD that were analysed for spot changes as in figure 1. Protein spots 6001 (a) and 6003 (b) were identified as changing with time on PD by PDQUEST software based on spot volume density. These were excised from the gel and subjected to MALDI-TOF Mass spectrometry. The proteins were identified as fibrinogen γ -chain (a) and heparan sulphate proteoglycan (HSPG) (b). Graphs show a single spot volume density at all 10 timepoints from 1 x 10 gel run. Fibrinogen γ chain gel images depict changes occurring between 2 ½ & 5 years where as HSPG shows images up to 3 years.

Figure 2a
1270x952mm (120 x 120 DPI)

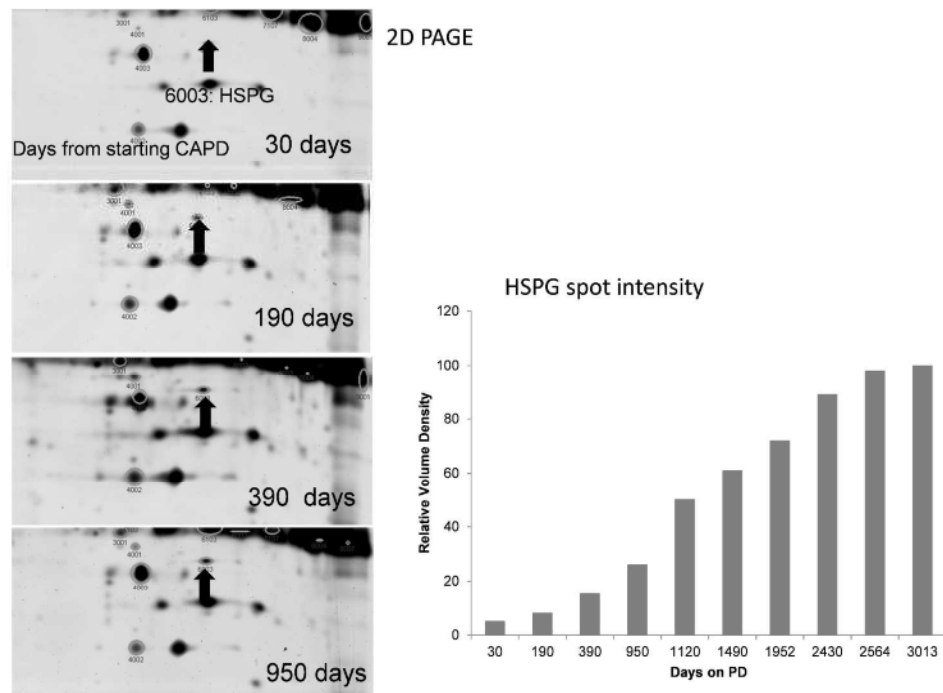


Figure 2: Fibrinogen γ -chain (a) and Heparan sulphate proteoglycan (b) are elevated in PD fluid with time on PD in a patient with stable membrane function (exemplar images).

Exemplar images from patient G05-068 (stable membrane function). 10 PD fluid samples were available, ranging from day 30 through to day 3013 on PD that were analysed for spot changes as in figure 1. Protein spots 6001 (a) and 6003 (b) were identified as changing with time on PD by PDQUEST software based on spot volume density. These were excised from the gel and subjected to MALDI-TOF Mass spectrometry. The proteins were identified as fibrinogen γ -chain (a) and heparan sulphate proteoglycan (HSPG) (b). Graphs show a single spot volume density at all 10 timepoints from 1 x 10 gel run. Fibrinogen γ chain gel images depict changes occurring between 2 ½ & 5 years where as HSPG shows images up to 3 years.

Figure 2b
1270x952mm (120 x 120 DPI)

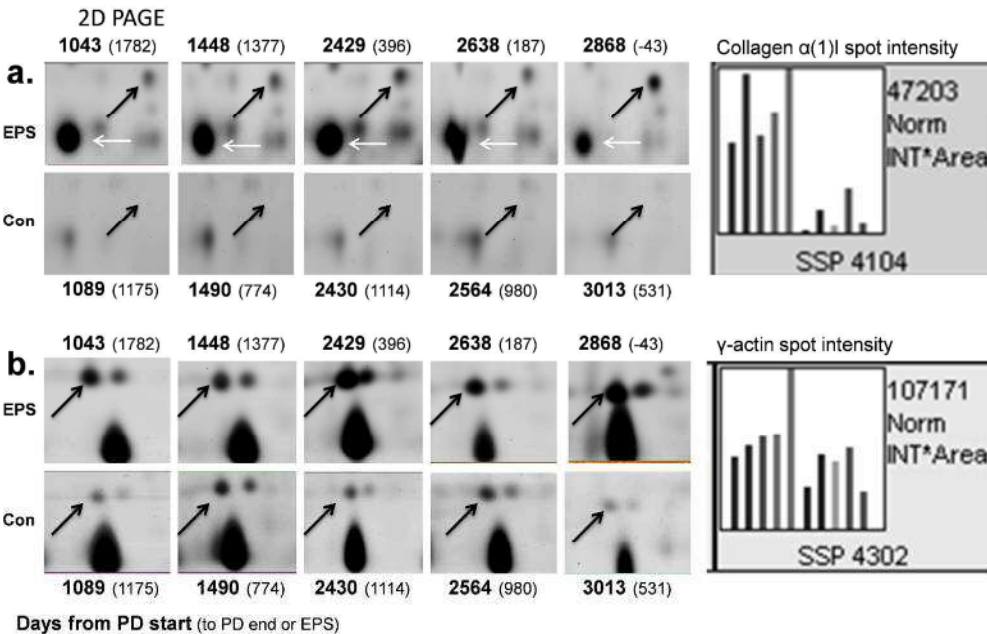


Figure 3: Collagen α(1)I (a) and γ-actin (b) are elevated in a patient with EPS 5 years before EPS diagnosis (exemplar images)

Exemplar images from GFS patients G05-072 (confirmed EPS) and G05-068 (stable membrane function). 5 PD fluid samples were available from patient G05-072, spanning days 1043 to 2868 of PD. These were matched to 5 samples from patient G05-068, based on time from start of PD and comparative 2D SDS-PAGE proteomics undertaken as in figure 1. Two spots as identified with a black arrow in both panels were seen to be consistently elevated in all EPS patients at all time points which was confirmed by volume densitometric analysis. This protein spots were excised from the gel and subjected to MALDI-TOF mass spectrometry. The proteins were identified as a fragment of collagen α1(I) (a) and as γ-actin (b). Of note, the spot identified by a white arrow in panel (a) at 55kDa was only elevated in this single EPS patient. Graphs show a single spot volume density at all 5 time points from 1 x 10 gel run with the first 5 bars being the identified spot in the EPS sample and the second 5 bars the stable patient plotted in chronological area.

Figure 3a, Figure 3b
1270x952mm (120 x 120 DPI)

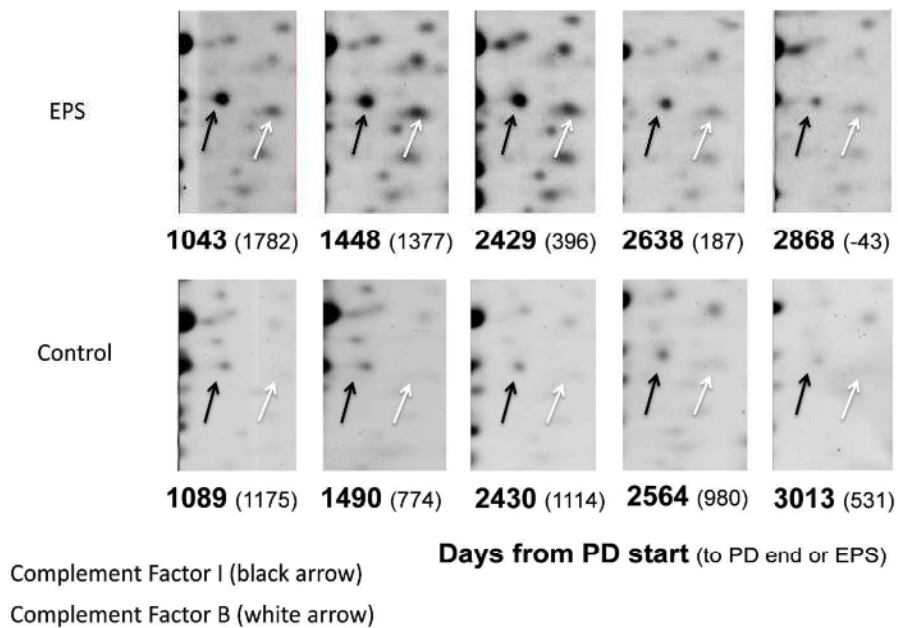


Figure 4: Complement factors I and B increase in a patient with EPS 5 years before diagnosis (exemplar images).!! + Exemplar images from GFS patients G05-072 (confirmed EPS) and G05-068 (stable membrane function). 5 PD fluid samples were available from patient G05-072, spanning days 1043 to 2868 of PD. These were matched to 5 samples from patient G05-068 based on time from start of PD and comparative 2D SDS-PAGE proteomics performed as figure 1. Two spots that were elevated by volume densitometry in EPS in this and 3 out of 4 other patient comparison runs were identified as complement factor I (black arrow) and complement factor B (white arrow).!! +

Figure 4
1270x952mm (120 x 120 DPI)

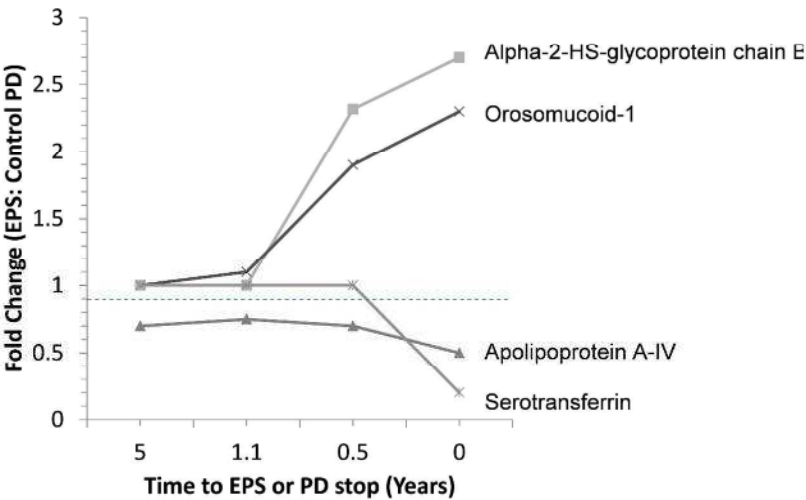


Figure 5: iTRAQ identifies 4 proteins with altered levels in an EPS patient compared to a matched control. Four PD samples from patient G05-072 (confirmed EPS) were matched with 4 PD samples from patient G05-068 (stable membrane function), by time to finishing dialysis. Each sample was precipitated in 3 volumes of acetone/10% TCA, re-dissolved & then buffer exchanged into triethylammonium bicarbonate (TEAB). 50 µg of protein was denatured in tris-(2-carboxyethyl)phosphine and reduced in methylmethane-thiosulfonate prior to trypsin digestion. Each sample was then labelled with a different isobariq tag using the 8 label iTRAQ system. All samples were mixed, fractionated by RP-HPLC and proteins identified by MODI-TOF MS. For each of 72 proteins detected, the ratio of each protein was calculated based on the abundance of each isobariq tag within that protein sample. Using this approach 4 proteins showed consistent trends. Orosomucoid-1 and α2-HS-glycoprotein chain B were both elevated in the EPS patient some 12 months before diagnosis, while Apolipoprotein A-IV was always low in EPS with a dramatic late drop in serotransferrin. Data shown represents fold change in the confirmed EPS patient compared to the patient with stable membrane function and is from a single experimental run.

Figure 5
1270x952mm (120 x 120 DPI)

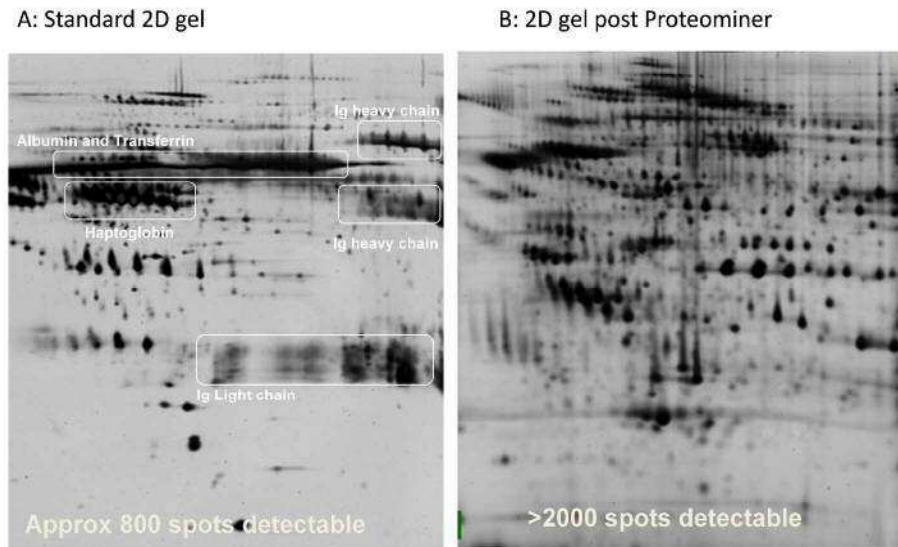


Figure 6: ProteoMiner™ allows detection of lower abundance proteins in PD fluid

A PD fluid volume equivalent to 15mg of protein was reduced to 500µl volume using a 3kDa molecular weight cut off concentrator. 10mg of protein was then subjected to the low abundance protein enrichment using the Bio-Rad ProteoMiner™ system using 20µl of beads. 100 µg of eluted protein and that from the original PD fluid samples was precipitated using 3 volume acetone/10% TCA and comparative analysis performed using 2D SDS PAGE proteomic analysis as in figure 1. The total number of resolved protein spots was calculated using PDQUEST.

Figure 6A, Figure 6B
1270x952mm (120 x 120 DPI)

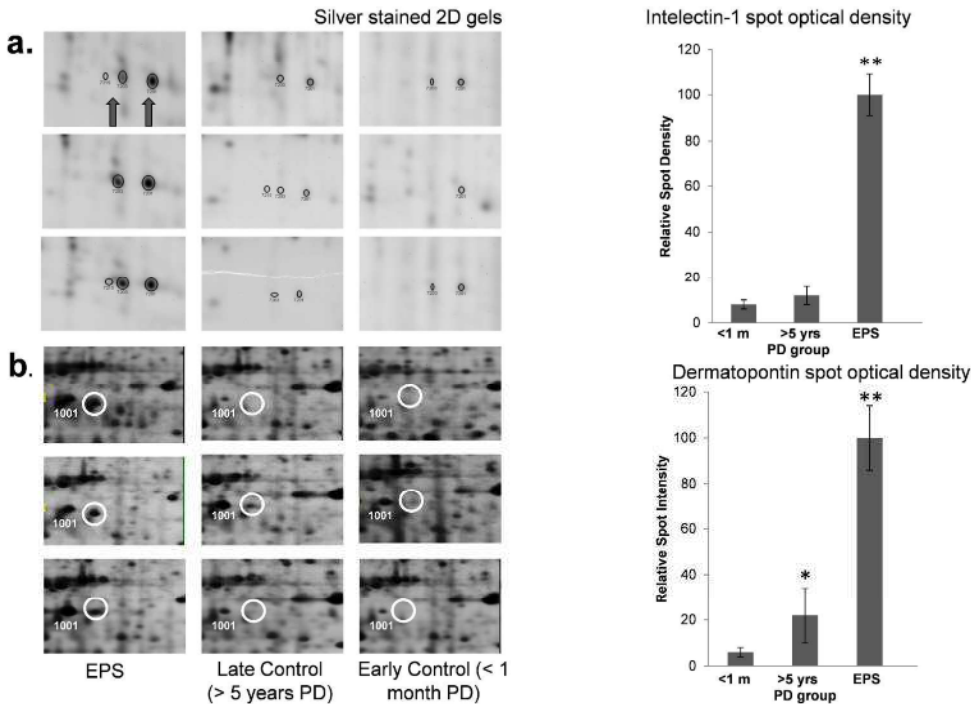


Figure 7: In protein mined PD fluid Intelectin-1 (a) and dermatopontin (b) are elevated in EPS. From a Greek cohort of PD fluid samples (University of Patras), fluid was taken from 3 patients with suspected EPS (2 of them confirmed post-portem), 3 patients who had remained on PD for more than 5 years but had no signs of EPS (late controls) and 3 patients with samples taken within the first month of starting PD (early controls). A volume equivalent to 15mg of protein was concentrated and subjected to ProteoMiner™ enrichment as in figure 6. Samples were then subjected to 2D SDS-PAGE analysis as in figure 1, with spots identified as different between the EPS (column 1), late controls (column 2) and early controls (column 3) identified using PDQUEST. Spot 7203 (a) was identified as being elevated in all 3 patients with EPS, which was confirmed by subsequent volume densitometry measurement of the spot in all 9 samples. Spot 1001 (b) was identified as being elevated in all 3 patients with EPS and one of the late controls, which was confirmed by subsequent volume densitometry measurement of the spot in all 9 samples. These spots were subsequently excised from the gel and identified by MALDI-TOF as intelectin-1 (a) and Dermatopontin (b). Spot volume densitometry from all 3 patients in each group was averaged with data presented as mean±SEM in the 2 bar graphs. Significance was determined by 1 way ANOVA, * p<0.05, ** p<0.01 compared to early PD control group.

Figure 7a, Figure 7b
1270x952mm (120 x 120 DPI)

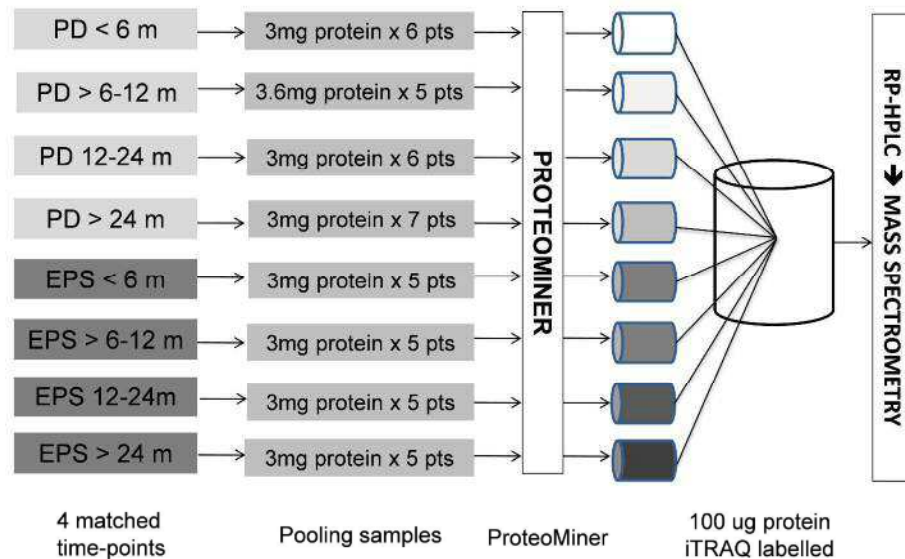


Figure 8: Analysis of pooled samples at four matched time-points using iTRAQ after treatment with ProteoMiner™.

Patient samples were pooled into 4 groups based on time (>24 mths, 12-24 mths, 6-12 mths, <6 mths) to developing EPS or stopping PD. Each pool consisted of equal amounts of protein from each sample available. Post pooling they were processed using ProteoMiner™, iTRAQ labelled, fractionated by RP HPLC and then subjected to tandem MS.

Figure 8
1270x952mm (120 x 120 DPI)

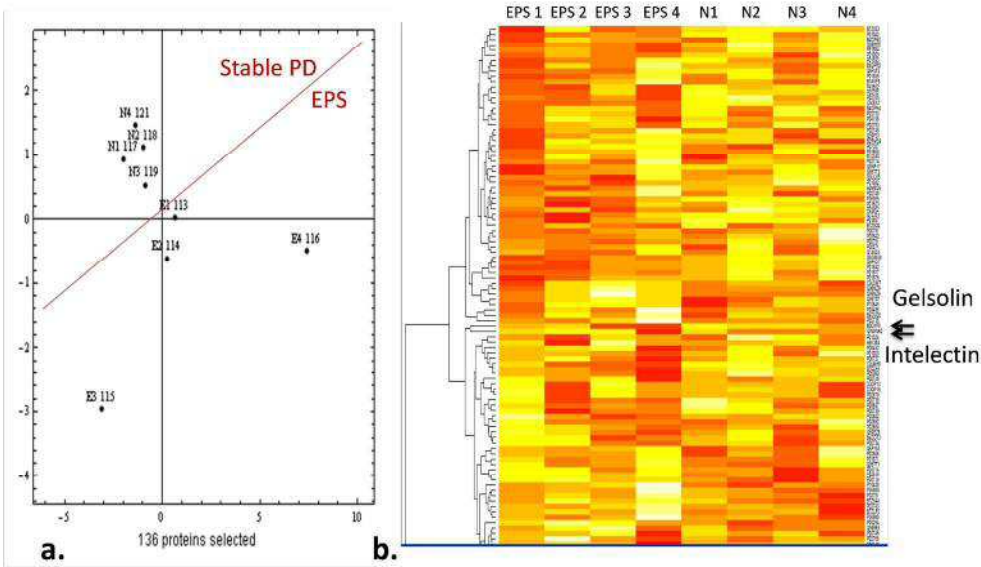


Figure 9: Hierarchical Cluster analysis (a) and heatmap (b) of proteins detected from proteome-mined pooled EPS PD effluent iTRAQ analysis. The relative contribution of each pooled cohort to the total level of each protein identified was made based on the abundance of each isobariq tag. The proteins detected in each cohort were then used to position each as a hierarchical cluster. E=EPS, N=Normal (stable PD), E1/N1 = >24 mths, E2/N2 = 12-24, E3/N3 = 6-12 mths and E4/N4= <6Mths to EPS or stopping PD (a). The variation in each protein detected in each cohort was then plotted as a heat map (b). Arrows indicate Intelectin-1 and Gelsolin. Data is from a single run.

Figure 9a, Figure 9b
1270x952mm (120 x 120 DPI)

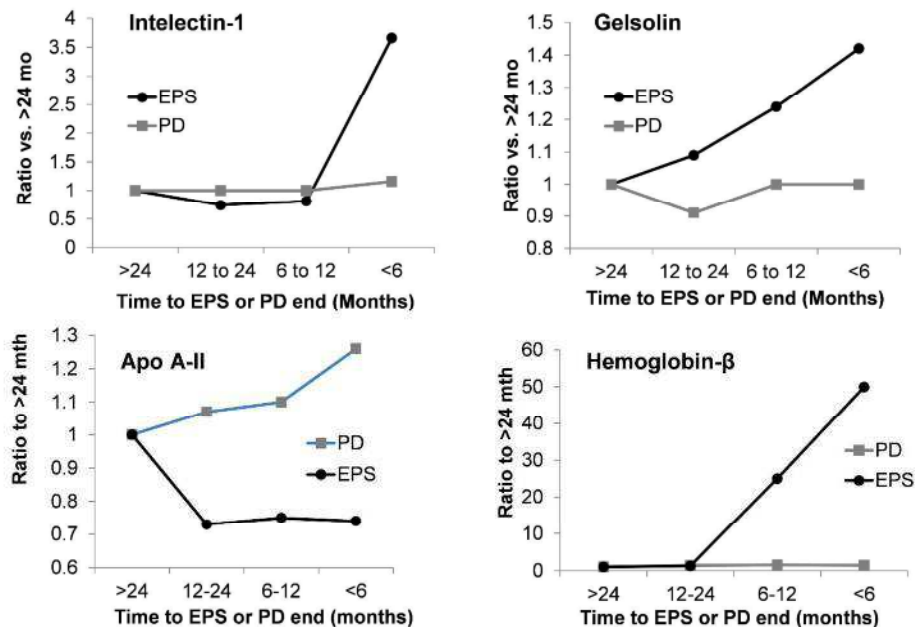


Figure 10: Relative changes in proteins showing progressive variation with time in pooled cohorts of EPS patients subjected to protein mining and ITRAQ analysis. Relative levels of intelectin-1, Gelsolin, Apolipoprotein A-II and Hemoglobin beta subunit were determined by calculating the ratio to the >24-month cohort level in the patients not developing EPS. Data represents ratio to >24month stable patient from a single run of pooled samples.

Figure 10
1270x952mm (120 x 120 DPI)

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Table 1: Proteins detectable by iTRAQ in whole proteome F

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| Serum albumin | Zinc-alpha-2-glycoprotein (Zn-alpha-2-glycoprotein) |
| Serotransferrin (Transferrin) | Beta-2-microglobulin form pI 5.3 |
| cDNA FLJ78387 | Ig gamma-2 chain C region |
| Short peptide from AAT (SPAAT) | Fibrinopeptide A |
| Haptoglobin beta chain | Alpha-1B-glycoprotein |
| Fibrinogen alpha chain, isoform CRA_c | Alpha-1-acid glycoprotein 2 (AGP 2) (OMD 2) |
| Apolipoprotein A-I(1-242) | Complement component 4A (Rodgers blood group) |
| Cyclosporin A transporter 1 | cDNA FLJ53691, highly similar to Serotransferrin |
| Trypstatin | Fibrinogen beta chain, isoform CRA_e |
| Apolipoprotein A-IV (Apo-AIV) (ApoA-IV) | Low molecular weight growth-promoting factor |
| Alpha-1-acid glycoprotein 1 (AGP 1) (OMD 1) | Alpha-2-HS-glycoprotein chain B |
| Complement C3c alpha' chain fragment 2 | Complement factor H |
| Ig gamma-3 chain C region | LVV-hemorphin-7 |
| Ig alpha-1 chain C region | cDNA FLJ51265, similar to Beta-2-glycoprotein 1 |
| Alpha-2-HS-glycoprotein chain B | Putative uncharacterized protein AZGP1 |
| Hemopexin | Complement factor B Bb fragment |
| Alpha-1-antichymotrypsin His-Pro-less | Ig kappa chain V-III region NG9 |
| Fibrinogen gamma chain, isoform CRA_a | Leucine-rich alpha-2-glycoprotein (LRG) |
| Alpha-2-macroglobulin (Alpha-2-M) | Ig kappa chain V-III region CLL |
| Ig kappa chain C region | Histidine-rich glycoprotein, isoform CRA_a |
| Transthyretin | Cystatin-C |
| HCG1778670 | Complement component C9b |
| Retinol binding protein 4, plasma, isoform CRA_a | Myosin-reactive immunoglobulin heavy chain variable region |
| cDNA FLJ53327, highly similar to Gelsolin | Complement factor D |
| | Ig kappa chain V-I region EU |

D fluid

Vitamin D-binding protein (DBP) (VDB)
Antithrombin
Cryocryoglobulin CC1 kappa light chain variable region
Cryocryoglobulin CC2 lambda light chain variable region
cDNA FLJ37971 fis, clone CTONG2009958, highly similar to
CERULOPLASMIN (EC 1.16.3.1)
cDNA FLJ39644 fis, clone SMINT2004037, highly similar to CHLORIDE
CHANNEL PROTEIN 7
cDNA FLJ52255, highly similar to Angiotensinogen
Thrombin heavy chain [CHAIN 1]
Apolipoprotein C-III (Apo-CIII) (ApoC-III)
Ugi-Y3
Inter-alpha-trypsin inhibitor heavy chain H1 (Inter-alpha-inhibitor heavy chain
1) (ITI heavy chain H1) (ITI-HC1) (SHAP)
Prostaglandin-H2 D-isomerase (PGD2 synthase) (PGDS2) (PGDS)
IGL@ protein
Nuclear fragile X mental retardation-interacting protein 2 (82-FIP)
Full-length cDNA clone CS0DD006YL02 of Neuroblastoma of Homo sapiens
(human)
Zinc finger protein 527
Uncharacterized protein C7orf62
Kelch-like protein 3 [ISOFORM C]
Myosin-reactive immunoglobulin light chain variable region

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Table 2: Top potential hits for EPS bio markers

| Change in EPS PDE | | | | |
|-----------------------|--------|--------|-------|-------|
| | 2D Gel | 2D Gel | ITRAQ | ITRAQ |
| | FP | MP | FP | MP |
| γ-Actin | ↑ | | | |
| Collagen(α1) 1 | ↑ | | | |
| α1 antitrypsin | ↓ | | ↓ | |
| α-2-HS-glycoprotein B | | | ↑ | ↑ |
| Serotransferrin | | | ↑ | |
| Complement C4B | | | ↑ | |
| Complement B | ↑ | | | ↑ |
| Complement I | ↑ | | | ↑ |
| Apolipoprotein A-IV | ↓ | | ↓ | ↓ |
| Orosomucoid-1 | | | ↑ | ↑ |
| Intelectin-1 | | ↑ | | ↑ |
| Dermatopontin | | ↑ | | |
| RBP-4 | | ↑ | | |
| Gelsolin | | | | ↑ |
| Haemoglobin b | | | | ↑ |
| Apolipoprotein A-II | | | | ↓ |

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; from 2D PAGE & iTRAQ proteomics

Frequency of occurrence in 2D gels (times of change)

6/6 patients (early./ elevated >3 yrs before EPS)

6/6 patients (early / > 3 yrs before EPS)

3/6 patients plus iTRAQ (slow reduction with time -v low at EPS)

NA. (mid/ 6 -12 months before EPS)

NA (early / > 12 months before EPS)

NA (early / > 12 months before EPS)

5/6 patients (early/elevated upto 6 years before EPS)

5/6 patients (early /elevated up to 6 years before EPS)

3/6 plus iTRAQ (late / from 12 months . -80% at EPS)

NA. (Early / > 1 yr before EPS)

3/3 patients & pooled (late/within 6 months of EPS)

3/3 patients (unknown)

3/3 patients (unknown)

Pooled. (Mid / elevated up to 1 year before EPS)

Pooled (late / elevated up to 12 months before EPS)

Pooled (late/ low for up to 12 mths before EPS)

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Table 3a: Global Fluid Study cohort - Demographic Data

| | 2D Gels | | iTRAQ pool | | | |
|--------------------------------------|------------------------------------|--|-----------------------------------|---------------------------------------|-----------------------------------|---------------------------------------|
| | | | Group 1 | | Group 2 | |
| | EPS (6 patients, 33 samples) | Control (6 patients, 33 samples) | EPS (5 patients, 5 samples) | Control (6 patients, 6 samples) | EPS (5 patients, 5 samples) | Control (5 patients, 5 samples) |
| Age (years) | 54.8 (15.4) | 51.8 (16.5) | 45.6 (12.4) | 55.0 (14.4) | 48.5 (16.3) | 54.3 (11.2) |
| Male Gender | 66.70% | 66.70% | 60% | 17% | 40% | 60% |
| Comorbidity (Low/Medium /High) | 50.0/50.0/0% | 50/33.3/16.7% | 60.0/40.0/0% | 50.0/33.3/16.7% | 60.0/40.0/0% | 60.0/0/40.0% |
| Previous peritonitis episodes | 0 (0-4) | 1 (0-4) | 1 (0-6) | 2 (0-6) | 2 (0-5) | 2 (0-3) |
| Months From PD Start | 35.2 (26.0) | 33.9 (25.2) | 55.1 (24.8) | 72.4 (51.2) | 73.3 (44.2) | 42.6 (15.8) |
| Months Until PD End | 29.5 (21.9) | 30.4 (16.7) | 1.8 (3.5) | 1.8 (0.6) | 8.9 (2.2) | 8.8 (2.3) |
| Urine volume (mls) | 663 (0-2128) | 816 (0-2092) | 60 (0-120) | 0 (0-940) | 170 (0-1322) | 120 (0-1508) |
| Icodextrin Usage | 36.40% | 26.50% | 40% | 66.70% | 20% | 24% |
| APD usage | 21.20% | 30.30% | 60.00% | 80.00% | 40% | 80% |
| Dialysate IL-6 (pg/ml) | 13.9 (0.1- 134.2) | 7.0 (0.0-87.8) | 75.9 (24.1- 134.2) | 24.8 (10.1- 45.1) | 10.7 (2.7-79.8) | 12.9 (2.4-52.9) |
| Plasma IL-6 (pg/ml) | 3.8 (0.5-54.7) | 1.1 (0.2-4.0) | 3.9 (0.7-11.1) | 4.1 (0.6-8.8) | 3.3 (0.9-9.6) | 4.2 (4.1-13.9) |
| Serum Albumin (g/L) | 33.9 (8.2) | 36.9 (4.7) | 30.0 (10.2) | 33.4 (5.5) | 35.0 (5.2) | 35.8 (3.6) |
| D/P Cr | 0.72 (0.14) | 0.69 (0.12) | 0.88 (0.08) | 0.89 (0.15) | 0.92 (0.19) | 0.81 (0.14) |

ed samples

| Group 3 | | Group 4 | |
|-----------------------------------|---------------------------------------|-----------------------------------|---------------------------------------|
| EPS (5 patients, 5 samples) | Control (6 patients, 6 samples) | EPS (5 patients, 6 samples) | Control (7 patients, 7 samples) |
| 48.8 (17.0) | 53.1 (18.4) | 47.4 (20.8) | 60.5 (19.8) |
| 80% | 83.00% | 40% | 71% |
| 40.0/60.0/0% | 33.3/50.0/16.7% | 40.0/60.0/0% | 57.1/42.9/0% |
| 1 (0-4) | 2 (0-4) | 0.5 (0-2) | 1 (0-4) |
| 38.6 (29.4) | 31.5 (17.6) | 30.1 (24.6) | 32.8 (22.4) |
| 15.5 (8.9) | 15.6 (2.0) | 47.9 (11.9) | 47.9 (8.6) |
| 295 (0-1570) | 604 (0-1160) | 550 (0-2004) | 1216 (0-1305) |
| 60.00% | 68.20% | 33.30% | 79.20% |
| 40% | 66.60% | 0% | 0.00% |
| 14.6 (7.7- 1902.9) | 42.5 (0.7- 116.1) | 10.2 (4.6-45.1) | 4.3 (2.9-13.8) |
| 4.4 (0.5-31.2) | 2.0 (0.6-12.6) | 3.4 (0.9-10.1) | 1.0 (0.0-5.4) |
| 29.8 (10.6) | 35.7 (4.7) | 33.3 (9.2) | 38.8 (3.9) |
| 0.74 (0.12) | 0.83 (0.08) | 0.70 (0.14) | 0.64 (0.09) |

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Table 3b: University of Patras cohort - Demographic Data

| | EPS (n=3) | Controls (n=3) | New starters (n=3) |
|----------------------------------|------------------|-------------------|-----------------------|
| Age (years) | 59 (30-64) | 56 (50-80) | 45 (43-60) |
| Male Gender | 67% | 33% | 33% |
| Comorbidity (Low/Medium/High) | 67/0/33% | 67/33/0% | 33/67/0% |
| Previous peritonitis episodes | 1 (0-4) | 0 | 0 |
| Months From PD Start | 108 (61-178) | 85 (68-97) | <1 |
| Urine volume (mls) | 0 (0-200) | 800 (500-1000) | 1000 (600-1700) |
| Icodextrin Usage | 67% | 33% | 0% |
| APD usage | 33% | 33% | 33% |
| Serum Albumin (g/L) | 32 (29-33) | 34 (32-38) | 40 (36-40) |
| D/P Cr | 0.89 (0.74-0.91) | 0.62 (0.58-0.76) | 0.72 (0.67-0.73) |

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